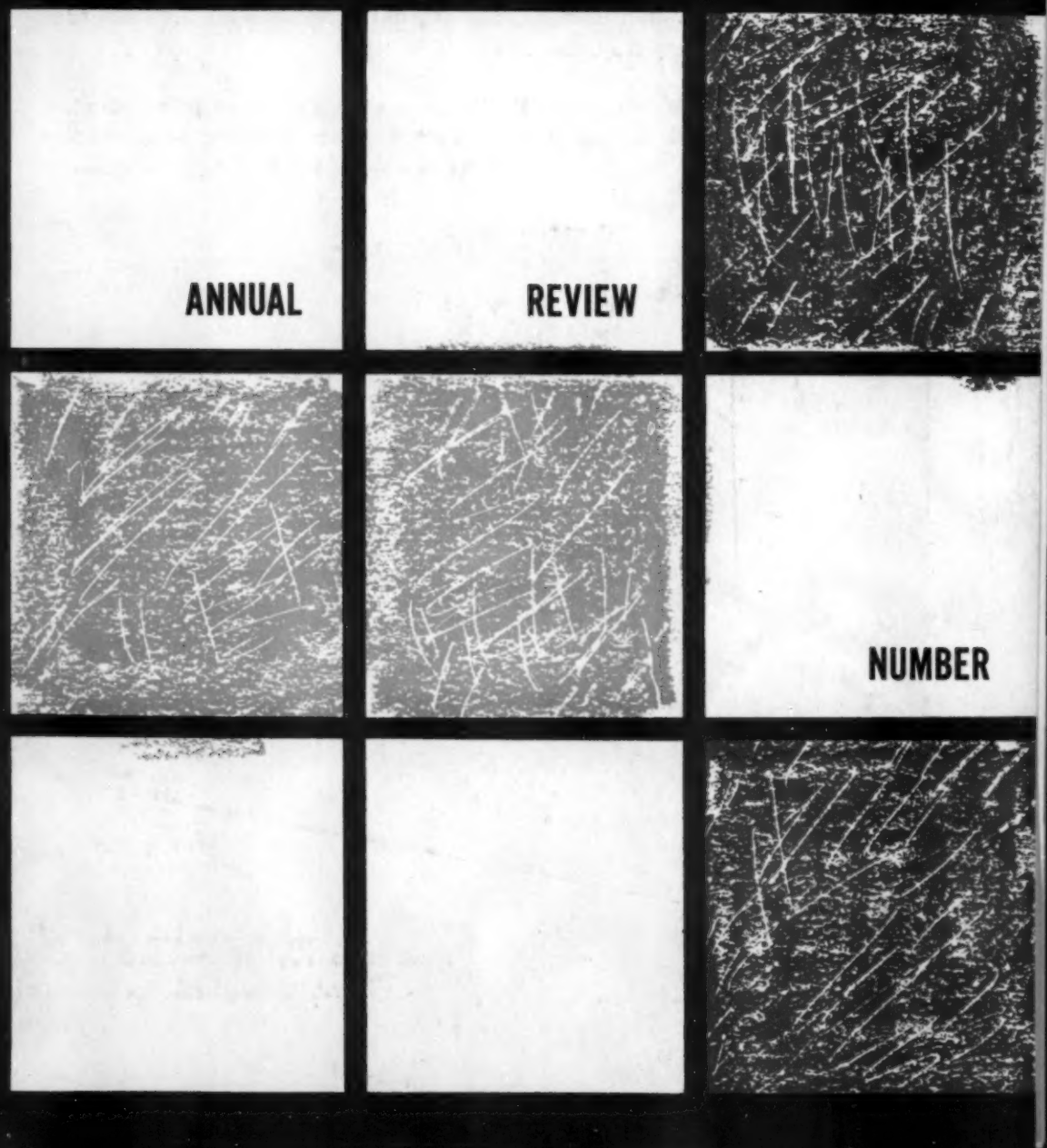
MINING engineering

MARCH 1955

ANNUAL REVIEW NUMBER



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MINING engineering

VOL. 7 NO. 3 MARCH 1955

COVER

Style of Herb McClure's cover design serves to announce the redesigned "heads" used throughout this issue, starting right with this page. It also carries a reminder that the largest Annual Review in ME's history starts on page 231.

FEATURES

ANNUAL REVIEW

TRANSACTIONS

DISCUSSION

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, 32, married; 5 years supervisory and management experience, desires foreign or domestic management responsibilities. Passable Spanish, good labor relations and production record, capable complete mine operation. M-117.

Mining Engineer, 32, married, B.S., M.S., and Ph.D. June 1955, all in mining engineering. Six years practical experience underground mining, also hydroelectric power construction and operation; 4 years mining research and teaching. Interested mining research, experimentation, and teaching. Speaks fluent Spanish, reads French and German. Available July; will consider any location. M-118-102-E-San Francisco.

Manager-Superintendent, 45, married; B.S. degree mining engineering; 21 years practical experience underground, open pit and quarry operations and heavy construction industry. Established reputation for production and organizational ability in managerial and supervisory positions in the U.S., Latin America, Asia, and Canada. Available immediately; any location acceptable. M-120-105-E-San Francisco.

Mine Chief Engineer, 39, married. Sixteen years experience open pit and underground mining, engineering and supervision. Broad background engineering, planning, developing, and in operations. Knowledge mine cost accounting, analysis; report writing, progress, cost, time, estimates. Familiar mining camp administration. Available 1 month. Housing and school required. M-119-101-E-San Francisco.

Geologist, Geophysicist, 39, single, A.B. 1938, M.S. 1940 Geology, New York University. Six years experience seismograph interpretation, knowledge of gravimetric, magnetic, and electrical methods of exploration. Desires position petroleum exploration. Available upon notification; location immaterial. M-121.

POSITIONS OPEN

Senior Metallurgist, graduate, 30 to 37, with experience in mineral dressing and extractive metallurgy, including sulphide flotation, for research and development laboratory. Must be able to work under limited supervision and willing to travel to operating plants to assist with metallurgical problems. Permanent. Salary open. Location, California. S140.

Mining Engineer experienced in small-scale open cut mining and jig milling, to supervise a going manganese operation. Salary, $7200 to $8400 a year. Location, South. W959.

Engineers. (a) Safety Engineer, grade I, 35, graduate mining engineer, with minimum of 6 years experience, 2 of which should have been in underground mining; familiar with state safety laws pertaining to mine operation, tunnel and caisson construction in free and compressed air; explosives and fireworks, transportation of dangerous articles; and the mine safety regulations of the U.S. Bureau of Mines and other mine safety authorities. Must have ability to qualify for a grade (A) blaster's permit. Will be under the direction and supervision of the chief mine safety engineer, to serve as his first assistant and be responsible for the effective operation of the field activities of the section and the work of the mine safety inspection. Salary, $6100 to $7100 a year. **(b) Safety Engineer, grade II,** 35, graduate mining engineer, minimum of 6 years experience, 2 of which should have been in underground mining; familiar with state safety laws pertaining to mine operation, tunnel and caisson construction in free and compressed air, explosives and fireworks, transportation of dangerous articles and the mine safety regulations of the U.S. Bureau of Mines and other mine safety authorities; some experience in the use and handling of explosives. Will be under the direction and supervision of the chief mine safety engineer or the safety engineer, grade I, to direct the work of the mine safety inspectors and participate in the development and activation of the engineering, educational, and enforcement programs of the section. Salary, $5400 to $6100 a year. Location, New Jersey. W680.

AVAILABLE

MINING ENGINEER—Age 36, production-cost conscious, interested in middle or top echelon responsibilities in management-operations with firm that must gear to peak productivity per man by utilizing high capacity mechanical equipment. Abreast of latest methods and machines. Able to organize, analyze, and present studies on operating results on special projects. Business training, ability to oversee examination, evaluation, layout, development, and operation of underground and surface mining. Now employed. Box 100.

FOR OPEN PIT

DART MODEL 30-SL

MODEL 30-SL—30 ton end dump. Full cab. 184" wheelbase. 300 to 350 HP Diesel Engine with or without torque converter. 100,000 lb. Dart planetary rear axle with 20" x 9" air brakes—25,000 lb. front axle with 20 1/4" x 5" air brakes. 16:00 x 25, 24-ply front tires—18:00 x 25, 32-ply rear tires. Hydraulic steering—20 Cu. Yd. Rock Body. Approximate Weight, 46,000#.

OR UNDERGROUND

DART MODEL 18-S-UG-S

MODEL 18-S-UG-S—18 ton underground truck powered by 275 H. P. Diesel Engine with torque converter and fully reversible transmission. Hydraulic motor operates steel apron conveyor. Equipped with exhaust scrubber. Hydraulic steering. Operates as shuttle car. Height, 66"; width, 10'8"; length, 28'. Approximate weight, 39,000#.

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Dart engineering has produced many "firsts" in design which today are standard. The DART line includes models for mining ranging from 10 ton capacity through 75 ton capacity . . . the most complete line of off-highway trucks . . . all are built to provide maximum haulage with minimum maintenance, even under the most rigorous conditions.

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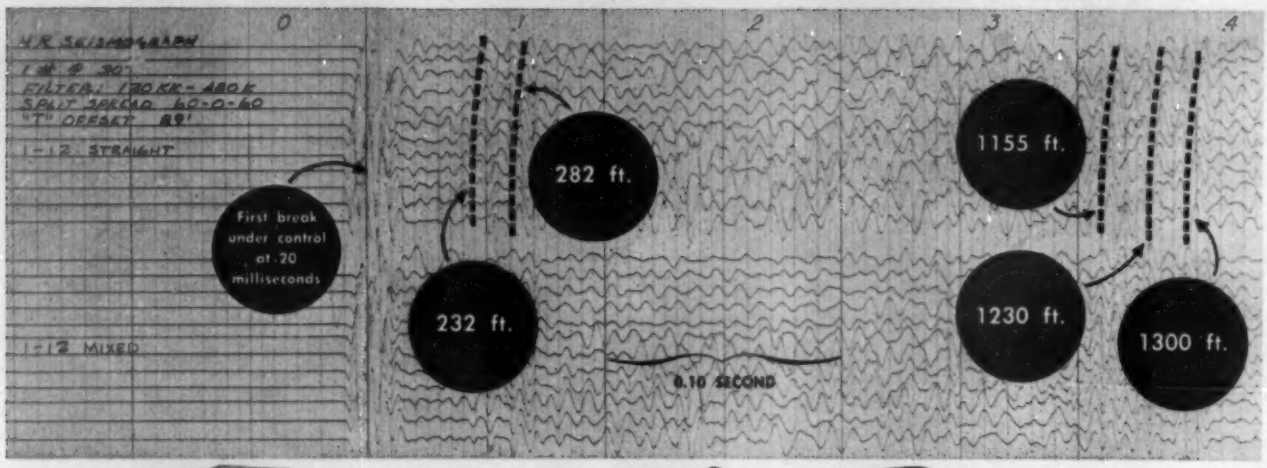

High Resolution

here's a new record for near-surface seismic data

If you're plagued with the problem of obtaining accurate near-surface seismic data, look carefully at the record illustrated here. With first breaks under control in 20 milliseconds, a reliable reflection was obtained at a depth of 232 feet. This record is typical of the results obtained by the new Houston Technical Laboratories High Resolution Seismic System. A major development in geophysical prospecting, the HTL portable HR System now makes possible reliable reflection surveys over a depth range of 100-2500 feet. It is especially designed for use in petroleum exploration, mining, ground water location, and civil engineering where shallow seismic information is vital.

WRITE for Technical Bulletin No. S-303 for additional information about how you can now make shallow seismic surveys.

use the HTL portable HR seismic system to determine:

- thickness of gravels and other unconsolidated materials;
- depth and extent of buried channels;
- location and delineation of shallow mineral beds or seams, dikes, pinchouts, lenses and similar features.

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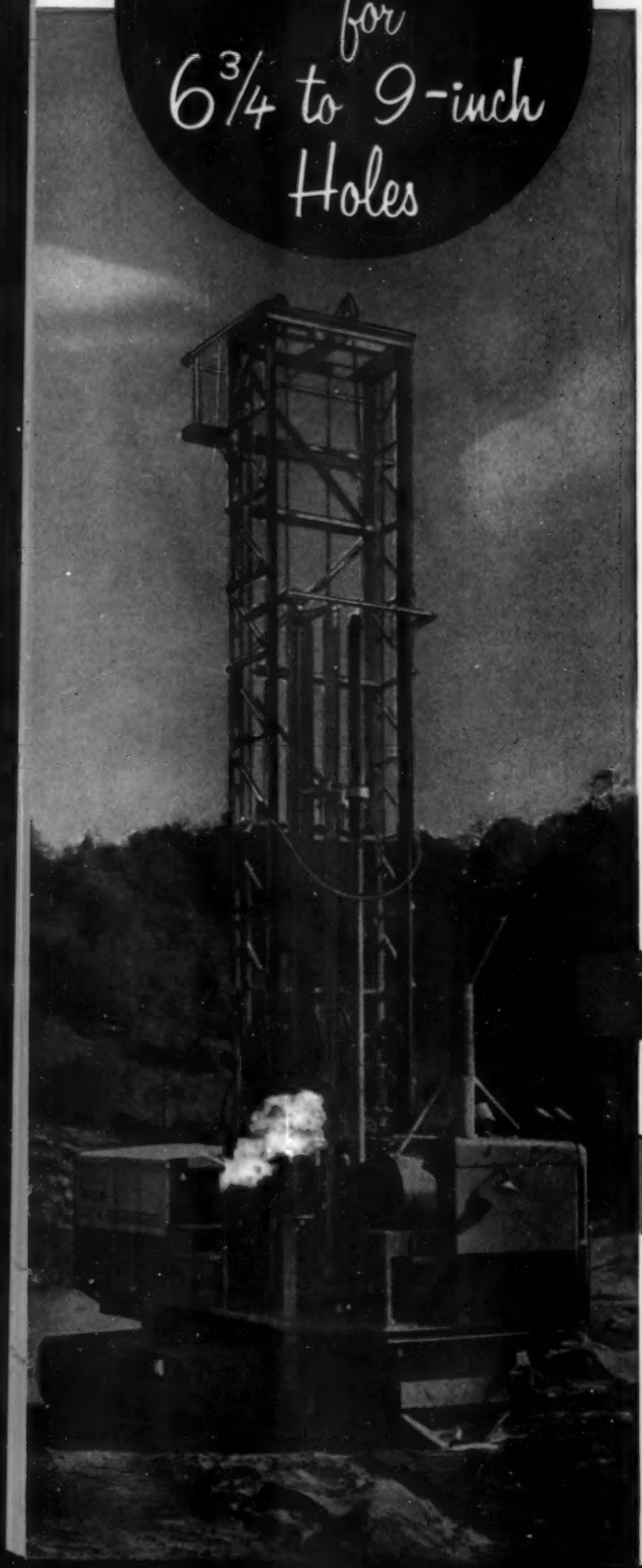
ANNOUNCING THE NEW BUCYRUS-ERIE

40-R

A Rotary Drill for 6¾ to 9-inch Holes



Here's big news for quarry and mine operators — Bucyrus-Erie has added another model to its line of rotary blast hole drills. It's the 40-R — designed for drilling 6¾ to 9-inch holes.

Like the bigger 50-R, this new drill features the flexibility of Ward Leonard variable-voltage control — an outstanding electrical control that gives the operator smooth instant command over rotation speed of drill pipe at all times. In addition, you have your choice of either electric or diesel-electric power *plus* these other outstanding field-proved advantages.

1. Hydraulically powered down pressure on the bit for maximum controlled penetration.
2. You can drill continuously for 27¾ feet before an additional drill pipe section is added.
3. Motor-controlled drill pipe rack holds four sections of pipe, any one of which can be moved into position over the hole and screwed tight mechanically without operator leaving control station.
4. Compressed air is used as a bit coolant and as a cutting remover. Fine cuttings are picked up and handled by a Roto-Clone precipitator; heavies pile up adjacent to the drill hole for use as stemming material.

Complete information is yours for the asking. Just fill in the coupon and mail it today.

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BUCYRUS-ERIE COMPANY
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Gentlemen: I'd like more information on your new 40-R.

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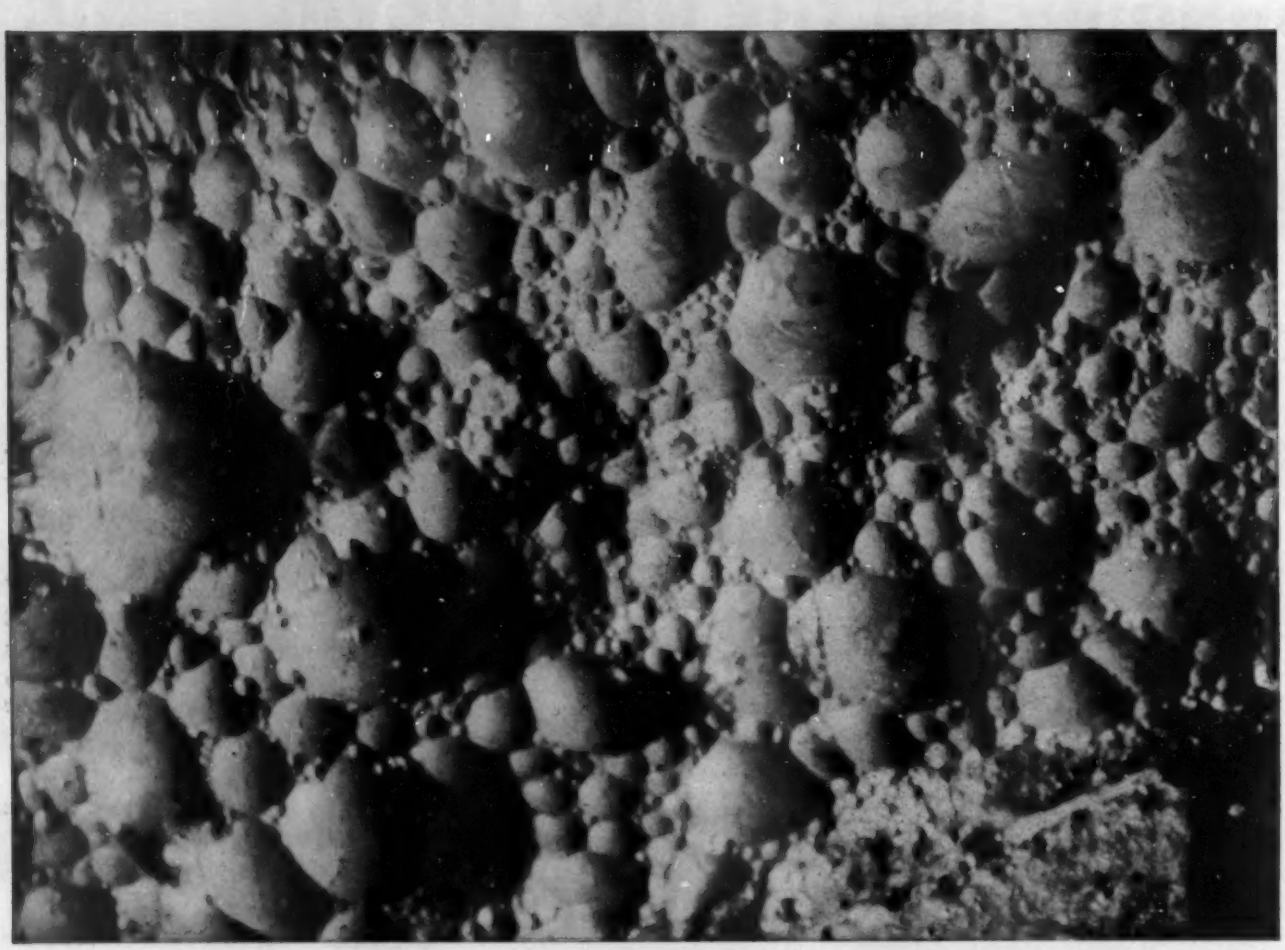

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List the characteristics of a good flotation agent and you'll see why Hercules Yarmor® F Pine Oil has remained a standard of quality for more than thirty years. Economy, strong froth with good volume, satisfactory texture, excellent cell-life stability—Yarmor F Pine Oil has them all.

Widely used as a frother for sulfide minerals such as zinc, copper, nickel, iron and lead sulfides, Yarmor F Pine Oil has also shown excellent results in the recovery of gold ores and native metals. This low-cost frother is also ideal for use in the benefication of nonsulfide ores such as coal, mica, quartz, graphite, feldspar, phosphate rock, and talc.

Other Hercules' flotation agents include Hercules Rosin Amine D Acetate, a siliceous mineral collector that is particularly suited for the phosphates. For information on these and other Hercules flotation agents, write:

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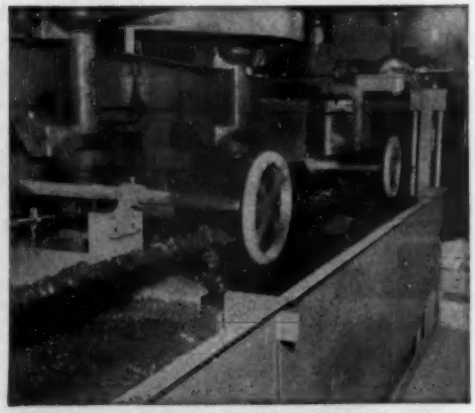

COAL FLOTATION—A growing market for Yarmor is in the recovery of fine anthracite and bituminous from silt.

HERCULES FLOTATION AGENTS

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Constructed with a Neoprene tube overlaid with high tensile steel wire braid. Top quality brown natural rubber cover. Has extremely high adhesion to carcass.

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BOOKS

Professional Engineering, Economics and Practice, by S. S. Aidlin, *Pelex Publishers Inc.*, $3.50, 148 pp., revised edition, 1954.—A planned development of the basic principles of engineering economics and professional practice, built around a review course the author has given to engineers and license-candidates for several years. This book is recommended for examinations by the National Council of State Boards of Engineering Examiners.

A Short Textbook of Colloid Chemistry, By B. Jirgensons and M. E. Straumanis, *John Wiley & Sons,* $8.00, 420 pp., 1954.—A study of the important and modern methods of light scattering, electrophoresis, ultracentrifugation, viscosity, electron microscopy, X-ray analysis, and related subjects. Using both organic and inorganic colloids as examples, the book emphasizes the dependence of various properties of colloidal systems on the sizes and shapes of the constituent colloidal particles and macromolecules. Basic facts and relationships are stressed, particularly in connection with practical problems, rather than speculation.

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten pct discount given whenever possible.

Mikroskopie Jer Erze, Aufbereitungsprodukte und Huttenschlacken, edited by Hugo Freund, *Umschau-Verlag,* available in U.S. from Stechert-Hafner Inc., approximately $24.00, 600 pp., 514 photomicrographs, 10 colored photomicrographs, numerous tables, on art paper, linen bound, 1954.—This book, a symposium of nine articles on the microscopy of ores, mill products, and slags, is part 2 of Volume II—*Mikroskopie der Bodenschatze* (mineral resources). Part 1 of Volume II, which has appeared, is an equally large book, dealing with the microscopy of coal and coke; Part 3, in preparation, is to deal with petroleum and potash salts. The complete *Handbuch der Mikroskopie in der Technik* will comprise eight volumes in 13 parts.

Minerals in World Industry, by Walter H. Voskuil, *McGraw-Hill Book Co. Inc.*, $5.75, 324 pp., 1955.—The author is chief mineral economist, Illinois State Geological Survey, and professor of Mineral Economics, College of Engineering, University of Illinois. His book is concerned primarily with the part played by minerals in economic productivity and in the establishment and maintenance of a high standard of living. After a discussion of iron as the core of the productive society based on minerals, the author considers fuels —coal, petroleum, natural gas, and "alternative fuels." Three chapters are devoted to plant-food minerals and the two concluding chapters deal with minerals in world affairs.

Conserving Natural Resources, by Shirley W. Allen, *McGraw-Hill Book Co. Inc.*, $5.50, 347 pp., 1955.—In his preface the author, professor emeritus, dept. of forestry, University of Michigan, says he has for years looked for a college textbook on this subject that frequently points out the social and economic aspects of conservation practice and that covers the nonrenewable or irreplaceable natural resources as well as those that are replaceable. This book fills that need.

Der Dammbau, Grundlagen und Geotechnik der Stau-und Verkehrsdämme, by Karl Keil, *Springer-Verlag,* Berlin, available in the U.S. from Stechert-Hafner Inc., approximately $17.25, 581 pp., 2nd edition, 1954.—A comprehensive treatise on the construction and engineering geology of earth dams, dikes, highway, and other embankments. The theoretical principles of shape, materials, and organization of the work precede the practical treatment of construction methods, equipment, quality control, settlement problems, and the causes and avoidance of failures. A 500-item bibliography is included.

(Continued on page 198)

Books Continued . . . . . .

Please Order the Books on These Pages from the Publishers

Minerals Yearbook 1952, Vol. II, Fuels, Superintendent of Documents, *U. S. Government Printing Office,* Washington 25, D. C., $2.25, 450 pp., 1954.—The Yearbook is now published in three volumes. This volume, devoted to mineral fuels, consists of chapters on each mineral-fuel commodity, as well as chapters reviewing the industry as a whole, a statistical summary, and an employment and injury presentation.

Report on the Committee on the Measurement of Geologic Time, 1952-1953, Publications Office, *National Academy of Sciences—National Research Council,* 2101 Constitution Ave., N. W., Washington, 25, D. C., $1.50, Publication 319, 187 pp., mimeographed, 1954.

Electrode Potentials of the Dissolution of Gold, by G. Thomas, *Dept. of Mines & Technical Surveys,* Mines Branch, Ottawa, Technical Paper No. 9, 25¢ Can., 14 pp., 1954.—The author is with the Div. of Mineral Dressing & Process Metallurgy.

List of Publications, University of Kansas, State Geological Survey, Lawrence, Kan. Revised Aug. 1, 1954. Available free.

Manual on Industrial Water, *American Society for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., $5.00, 430 pp., 1954.—A broad discussion of the nature and uses of industrial water, plus up-to-date testing methods and specifications developed by leading authorities. It is intended as a brief reference for executives and plant designers; individuals engaged in industrial operations involving the use of water; and analysts, operators of special instruments, engineers, and consultants.

A Preliminary Report on the Fluorspar Mineralization Near Challis, Custer County, Idaho, by Alfred L. Anderson, *Idaho Bureau of Mines & Geology,* University of Idaho, Moscow, Idaho, $1.00, 13 pp., maps in pocket, August 1954.

Textures of the Ore Minerals and Their Significance, 2d ed., by A. B. Edwards, *Australasian Institute of Mining and Metallurgy,* 399 Little Collins St., Melbourne, Australia, $6.95 for nonmembers, $4.71 for bona fide students (nonmembers), postpaid, 242 pp., 1954.—A series of lectures delivered to graduate students in the geology dept., University of Melbourne. While not claiming to be comprehensive, it attempts to bring together the significant ideas relating to the origin of mineral textures and their applications to geological and metallurgical problems. The book is almost the only available treatment in English of this subject. The approach, in the main, is genetic.

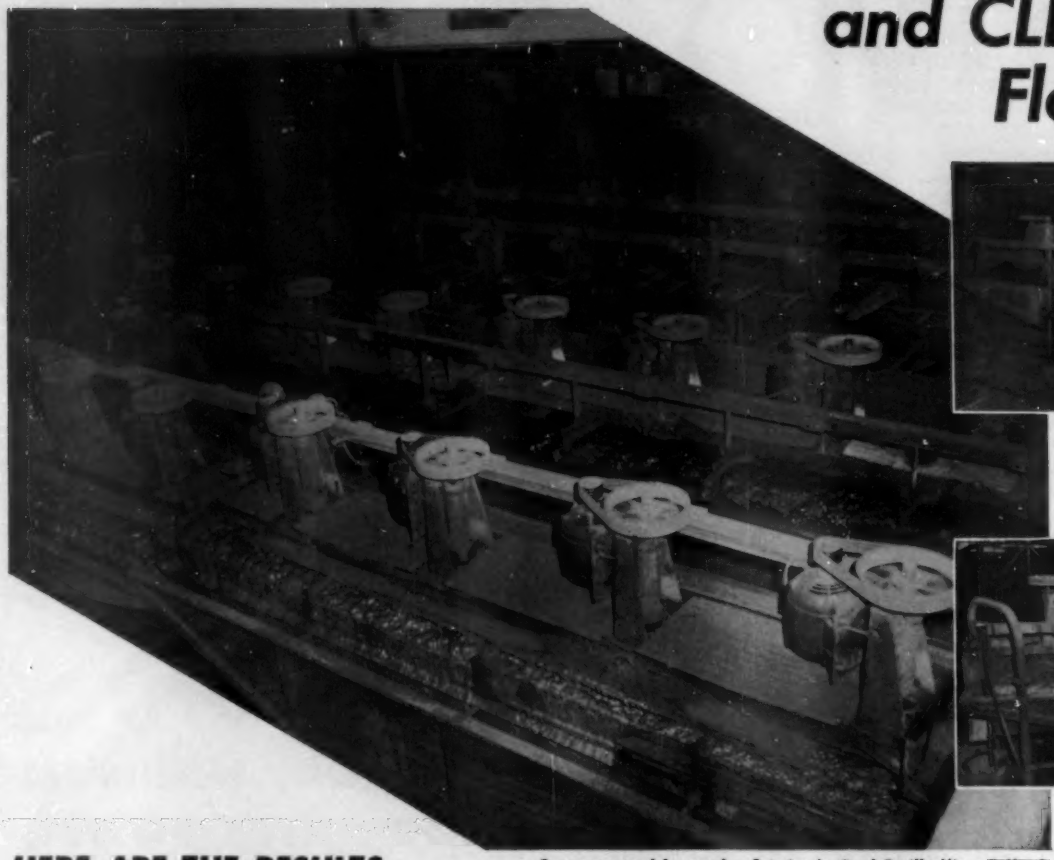
The Origin and History of the Earth, by Robert Tunstall Walker and Woodville Joseph Walker, *The Walker Corp.*, Box 1068, Colorado Springs, Colo., $5.00 postpaid in the U.S., $5.25 Canada and Mexico, $5.50 other countries, 244 pp., 1954.—For the past hundred years most geologists and astronomers have accepted the hypothesis that the earth is shrinking. The authors, economic geologists, with a joint span of experience covering more than 50 years of surface and underground observations, "were slowly and reluctantly forced to the opposite conclusion that the earth was increasing in volume. . . . This idea once adopted, the phenomena of vulcanism and orogency —heretofore inadequately explained —all fell into place like the parts of a jigsaw puzzle." Robert Tunstall Walker was formerly chief geologist, U. S. Smelting Refining & Mining Co., Salt Lake City, and his son, Woodville Joseph Walker, was formerly geologist, Resurrection Mining Co., Leadville, Colo. The general conclusions set forth in their interesting and well-illustrated book are proposed only as a hypothesis, "whose ultimate acceptance or rejection will depend upon further investigations by scientists of the evidence and assumptions on which it is based."

Uranium, Where It Is and How To Find It, by Paul Dean Proctor, Edmond P. Hyatt, and Kenneth C. Bullock, *Eagle Rock Publishers,* Box 1581, Salt Lake City, Utah, $2.50 bound, $2.00 paper, 84 pp., 1954.—A nontechnical guide, well-illustrated with maps and diagrams, for the trained geologist and engineer, as well as the novice prospector. The material is complete, covering not only field equipment, Geiger counters, U-V lamps, but claim staking, field procedure, selling, etc. The appendix lists ore-buying stations, AEC depository libraries, and addresses for sending samples for assay. All three authors are actively and successfully engaged in geologic exploration work.

The Cumberland Plateau Overthrust and the Geology of the Crab Orchard Mountains Area, Tennessee, by Richard G. Stearns, Bulletin 60, *Tennessee Div. of Geology,* G-5 State Office Bldg., Nashville, Tenn., $1.50, 46 pp., 8 fig., 5 pl.—A technical report of the geology of approximately 250 sq miles in northeastern Cumberland County and adjacent parts of Morgan County. Of primary interest to geologists and laymen seeking commercial coal or stone.

Milling Plants in Canada, Part 1: Operators of Concentrating Mills Treating Metallic Ores, Part 2: Operators of Plants Treating Industrial Minerals, prepared by Mineral Resources Div., *Mines Branch, Dept. of Mines & Technical Surveys,* Ottawa, Canada, 25¢ Can., 1954.

FAGERGRENS pay off in both ROUGHER and CLEANER Flotation



Fagergrens used for rougher flotation by Pend Oreille Mines & Metals Co., Metalline Falls, Wash. Zinc circuit in foreground, lead circuit in center; duplicate circuits being installed in background.

Fagergren cells in lead cleaner flotation circuit.

Fagergren cells in zinc cleaner flotation circuit.

HERE ARE THE RESULTS OBTAINED BY A MAJOR LEAD-ZINC PRODUCER

48 Fagergren Flotation Machines are used by Pend Oreille Mines & Metals Co. in flotation circuits having a capacity of 1600 tons per day. The ore is hard and abrasive with lead (as galena) occurring in coarse crystals and zinc (as sphalerite) finely disseminated in the gangue. Specific gravity of ore is 2.7 to 2.8.

Fagergren's highly efficient performance in this application produces superior metallurgical results, as follows:

1. Lead concentrate grade averaging well over 70% lead.
2. Zinc concentrate grade running close to 60% zinc.
3. Recoveries of approximately 95% lead and zinc in respective concentrates.
4. Exceptionally low lead and zinc tailing assays.

High Metallurgical Efficiency, as demonstrated above, is not unusual with Fagergrens. It is based on the faster rate of flotation and greater flotation recovery made possible by Fagergren's exclusive Rotor-Stator design. This superior agitating mechanism is unmatched for effective pulp circulation and aeration with resulting greater capacity per cubic foot of cell volume and higher mineral recovery.

Specify Fagergrens for your next installation or as replacements for older, less efficient machines. Send today for free copy of Fagergren descriptive bulletin and for recommendations concerning your flotation problem.

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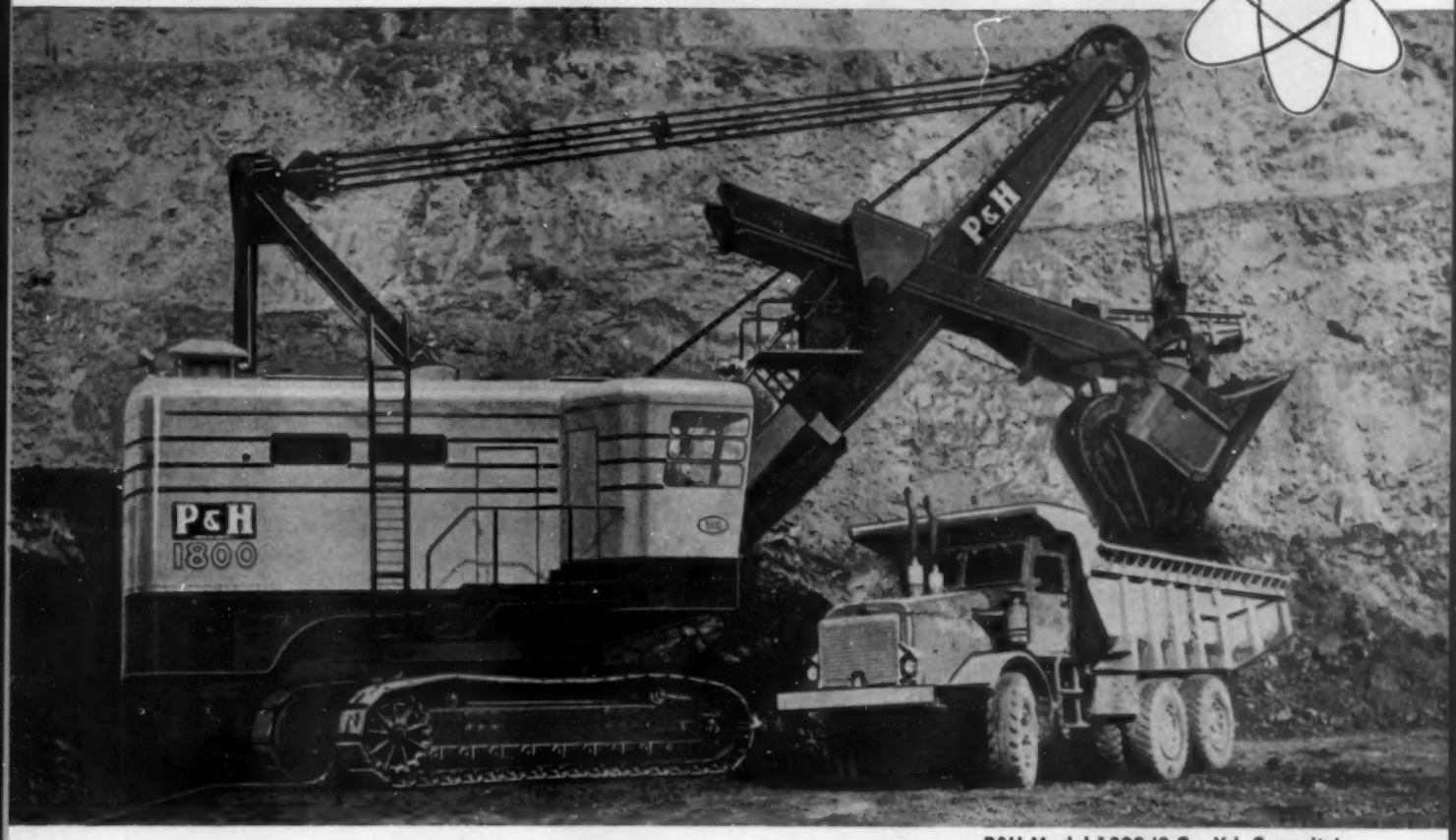

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ONE RESPONSIBILITY. All electrical equipment on P&H Electric Shovels is designed and built specifically for shovel service — not adapted for it. And P&H, the builder, takes the entire responsibility for service. There's no buck-passing among suppliers. P&H service is tailored to your needs.

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*T.M. of Harnischfeger Corporation for electro-magnetic type coupling.

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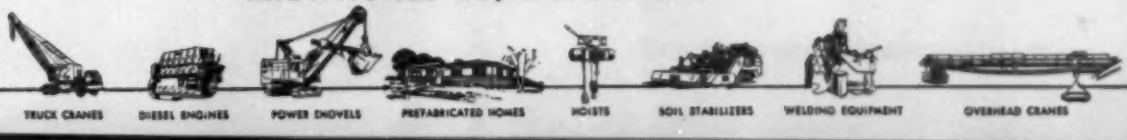
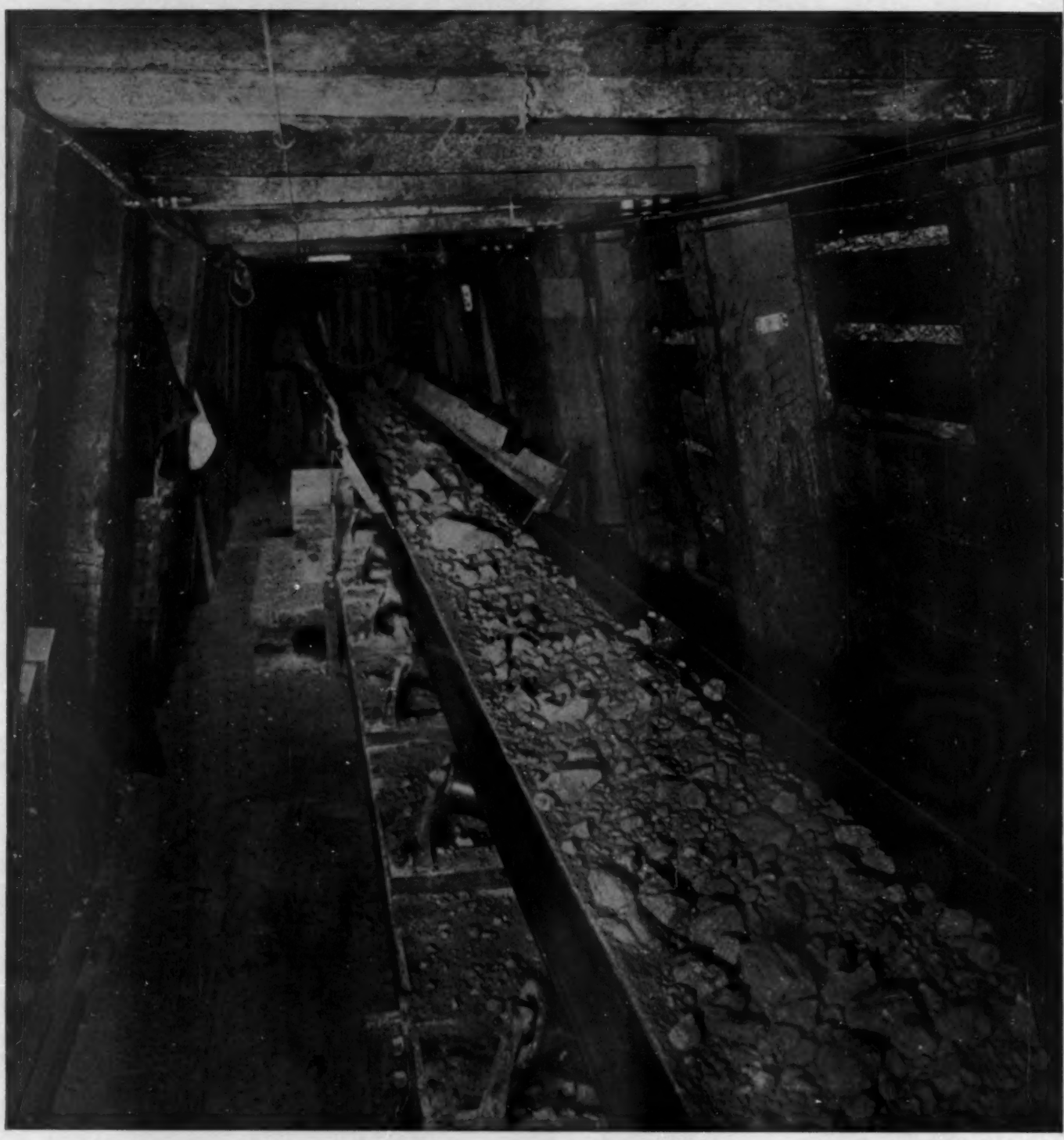


A Complete Line of Belt



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Whenever you handle ore in bulk—underground, overland, in open pit or mill—Hewitt-Robins belt conveyor systems will provide the most efficient, most economical answer.

Hewitt-Robins designs and manufactures a complete line of belt conveyor systems . . . Sectionalized Ore Mine —Mine-Type Shuttle—Engineered . . . each one matched to the requirements of a particular type of ore handling operation.

All Hewitt-Robins belt conveyor systems are backed by unified responsibility. Because Hewitt-Robins is the only company that designs and manufactures *both* the belting *and* specialized machinery, and assumes full responsibility for successful operation from drafting board to installation.

ENGINEERING DATA

FOR BLOCK CAVING: Hewitt-Robins sectionalized ore mine conveyors maintain a steady flow of ore in haulage drift or sub-drift under grizzly level . . . eliminate down time for timber repairs and replacement . . . assure less chance of breaking in stopes or arching in the chutes . . . provide faster withdrawal of block being mined.

FOR UNDERGROUND HAULAGE: Hewitt-Robins sectionalized ore mine conveyors and mine-type shuttle conveyors provide continuous transportation from working face to points of beneficiation. The mine-type shuttle conveyor answers the problem of truly continuous mining . . . it follows the working face and at the same time maintains a fixed transfer point through a fixed tripper—unit is extendable or retractable up to 600' . . . Sectionalized ore mine conveyors for main and stope haulage are available in 8' and 12' sections suitable for 3' and 4' idler spacing with choice of 24", 26", 30", 36", 42" and 48" belt widths.

FOR OVERLAND, OPEN PIT AND MILL HAULAGE: Hewitt-Robins engineered conveyors are designed to meet particular local conditions. They are available in belt widths from 16" up to 72" . . . are supplied with anti-friction, offset demountable-type idlers with 2½" diam. idler rolls (where minimum vertical clearance is available) up to 7" diam. rolls (where conditions require).

Here is a partial list of

HEWITT-ROBINS PRODUCTS

that will help you cut handling costs and increase operating efficiency.

MACHINERY

- Belt Conveyors
- Belt & Bucket Elevators
- Car Shakeouts
- Conveyor Idlers
- Dewaterizers
- Mechanical Feeders
- Foundry Shakeouts
- Mine Conveyors
- Reclaiming Systems
- Screen Cloth
- Stackers & Trippers
- Vibrating Conveyors & Screens

INDUSTRIAL RUBBER PRODUCTS

BELTING:

- Conveyor
- Elevator
- Transmission

HOSE:

- Acid
- Air & Air Drill
- Barge Loading
- Dust Suction
- Fire
- Fuel Oil & Gasoline
- Gasoline Pump
- Mud Pump Suction
- Oil Suction & Discharge
- Propane-Butane
- Road Builders'
- Rotary Drilling
- Sand Blast
- Sand Suction
- Sea Loading
- Servall®, All-Service
- Steam
- Tank Car & Tank Truck
- Vacuum & Air Brake
- Water & Water Suction
- Welding, Twin-Weld®

•

For information and service on industrial rubber products, contact your Hewitt-Robins Industrial Supply Distributor. Through his complete stock of Hewitt-Robins Rubber products, and his familiarity with local field conditions, he can fill your supply needs promptly and correctly. See Classified Phone Book for the Hewitt-Robins Industrial Supply Distributor serving your area.

1444

INCORPORATED

DOMESTIC DIVISIONS: Hewitt Rubber • Robins Conveyors • Robins Engineers • Restfoam
FOREIGN SUBSIDIARIES: Hewitt-Robins (Canada) Ltd., Montreal • Hewitt-Robins Internationale, Paris, France • Robins Conveyors (S. A.) Ltd., Johannesburg • **EXPORT DEPARTMENT:** New York City.

Manufacturers News

News
Equipment
Catalogs

• FILL OUT THE CARD FOR MORE INFORMATION •

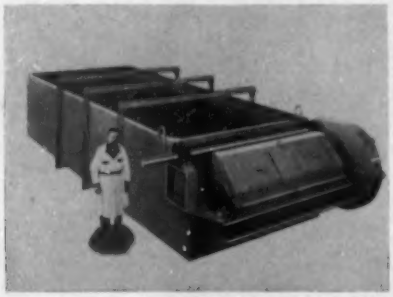
Self-propelled Scraper

First machine completely designed by the new *LeTourneau-Westinghouse Co.* is a 23-yd, single-engine,

self-propelled scraper, the B Tournapull. Struck capacity of its model B scraper is 18 yd—its heaped capacity 23 yd without sideboards. Overall length is 40 ft 6 in. Power is from a 293 hp diesel with 10 gear ratios ranging from 2.4 to 28.4 mph. **Circle No. 1**

Log Washer

New king-size log washer is being marketed by *Eagle Iron Works.* Log, which is the shaft and paddles, is 48 in. diam. Tub width is 9 ft 4 in.



and tub length is 30 ft. Unit is rated at 150 tph and is powered by 150 hp electric motor through an enclosed reduction unit. **Circle No. 2**

Bore Hole Geiger Counter

A new lightweight, compact instrument that makes possible radiometric logging of bore holes without expensive core drilling has been announced by *Jeb Instruments.* Easily handled by one man, the Depthmaster is self-contained. It features a 900 v Geiger tube, 500 ft of cable on a level winding reel, footage indicator, brake, and is mounted in a heavy gage steel case with ball bearings. Total weight is 42 lb. The instrument has a 4½-in. meter, reading in three sensistivity ranges and two time constants. **Circle No. 3**

Earth Drill

A heavy duty drill, model YT earth drill, has been added to the *Allis-Chalmers'* line of matched attachments for its 50-hp HD-5 crawler tractor. Designed for use along with other front-mounted attachments for the HD-5, the drill is mounted with-

out disturbing either front-mounted shovel or dozer already on the tractor. Model YT is driven through tractor power take-off. Drilling position adjustment is hydraulically controlled, and with the series of flights available, the new drill can bore holes up to 24-in. diam. **Circle No. 4**

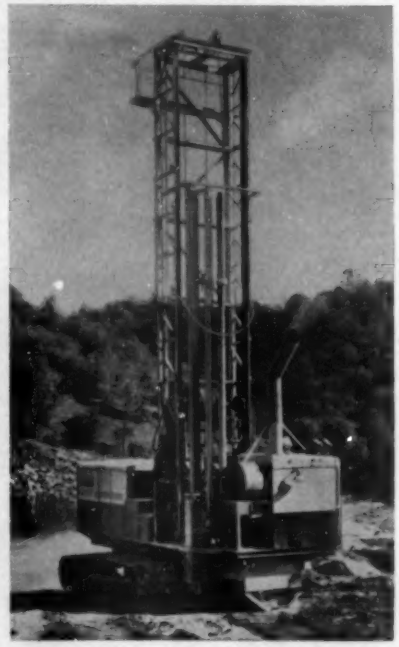
Refraction System

Very Low Frequency seismic refraction system—with special ampli-

fiers linear from 1 to 50 cycles and unique refraction seismometers with a natural frequency of 2 cycles per sec—has been introduced by *Houston Technical Laboratories.* It is reported that the VLF system easily records low frequencies and overcomes previous shortcomings of the refraction method of seismic exploration. High system sensitivity also permits the use of much smaller powder charges. **Circle No. 5**

Blasthole Drill

Rotary blasthole drill for putting down medium-diameter holes is offered by *Bucyrus-Erie Co.* Designed along the same lines as the larger



50-R, the 40-R is available with electric or diesel-electric power and is equipped to drill 6¾ to 9-in. diam holes. The drill is crawler-mounted. **Circle No. 6**

King-Size Cartridges

Long-length, small-diameter cartridges are in production by *Hercules Powder Co.* It is claimed that the cartridges make possible more uniform fragmentation. They are available in 24, 20, 16, and 12-in. lengths and up to 2-in. diam. **Circle No. 7**

Breathing Device

Mask designed by *Mine Safety Appliances Co.'s* supplies workers with oxygen or air as desired. The MSA mask comes in two models, the Air-Mask and the O_2-Mask. Either combines a supply of air or oxygen with a demand regulator to provide 30-min service in highly toxic or oxygen-deficient atmospheres. A backmounted cylinder, supported by a lightweight metal frame, is held by nylon harness. **Circle No. 8**

Free Literature

(21) MODERN LOCKER ROOMS: *Moore Co.* has a 40-page study on changerooms with overhead locker-baskets, a new concept in design that elevates clothing to the ceiling where it is quickly dried and aerated; fresh for the next day.

(22) TRACTOR: The 30-page catalog from the Tractor Div., *Allis-Chalmers Mfg. Co.*, has a 3-page cutaway view of the HD-9 diesel-powered crawler tractor. Other illustrations help tell the engineering, mechanical, and operation story of the HD-9 and a group of on-the-job photos tie the tractor's versatility and performance ability to the operator's job requirements.

(23) MAGNESIA REFRACTORIES: "Ramset—New and Unusual Applications" from *Basic Refractories Inc.* discusses new uses for this magnesia ramming mix, designed for original bottom construction and maintenance of open hearth and electric steel producing furnaces. Among lesser known applications are: rammed runners, short spouts and aprons, furnace construction, mold stools, and setting ladle nozzles.

(24) CINDER CARS: *M. H. Treadwell Co.'s* bulletin 61 is an 11-page catalog illustrating cinder cars. More than 2000 of this company's cars have been placed in service in plants of ferrous and nonferrous metal producers in U.S. and other countries.

(25) TRANSIT CRANE: *Bucyrus-Erie's* 15-B transit crane is a mobile ½-yd crane-excavator, easily converted to shovel, dragline, clamshell, or dragshovel. Booklet 15-B-TC-1 contains job application photos, close-ups of mechanical features, specifications, and working ranges, plus a description of the machine's major advantages.

(26) PERMANENT MAGNETS: *Eriez Mfg. Co.*, which makes permanent, nonelectric magnetic separators, has a 16-page general catalog showing the many types of magnetic installations produced by this company. One of Eriez' recent developments is Magnalarm, a magnetic separator with a built-in alarm system that tells you when your magnet needs cleaning.

(27) AIRMASTER: *Le Roi Div.*, Westinghouse Air Brake Co. has a 4-page bulletin illustrating the many exclusive features on the 85 cfm Airmaster. A cross-section view of the

one-unit engine-compressor design shows how a single cooling system, one lubrication system, and one crankcase and crankshaft simplify any maintenance that might occur.

(28) ENGINEERING IRONS: *International Nickel Co.* compiled "Guide to the Selection of Engineering Irons" primarily for design engineers. This 28-page basic reference bulletin presents the many valuable characteristics of modern nickel cast irons and illustrates their broad acceptance.

(29) LUBRICATION OF SOLIDS: *Alpha Corp.* has published "Properties and Uses of Pure Molybdenum Disulphide as a Lubricant," a general discussion of the principle of lubrication by solids and description of the value of MoS_2 in extreme pressure lubrication applications.

(30) INDUSTRIAL ENGINES: A technical bulletin from the industrial engine dept., *Willys Motors Inc.* describes two 6 cylinder industrial engines. Folder contains power curves, specifications and illustrations.

(31) SINTERING: Bulletin shows how Dravo-Lurgi sintering, pelletizing, and sinter cooling machinery will enable the U.S. iron and steel industry to utilize ore fines. Time-tested German improvements are augmented by *Dravo's* more than 60 years of experience in engineering, fabrication, and construction.

(32) MATERIALS HANDLING: Among the well-illustrated articles in the current issue of *Stephens-Adamson's* "The S-A Conveyor" are: "Coal Conveying—26 Cars per Day," "Zipper Whips Corrosion Problems," and "Labrador Ore Moves From Seven Islands."

(33) FILTER FABRICS: *Wellington Sears Co.'s* 16-page illustrated booklet, "Filter Fabric Facts," makes no claim to being a complete technical manual. However, it summarizes a number of general and specific facts, not believed to have been generally available to the processing industries in any one publication before.

(34) TURBINE-GENERATORS: *General Electric Co.'s* booklet GEA-3277C describes turbine-generators, rated from 2,500 to 40,000 kw. Condensing and noncondensing applications for electric utilities and industrial plants as well as turbine applications are covered.

(35) SOIL TESTING: Descriptions and illustrations of more than 1250 items of apparatus for engineering tests of soils, concrete, asphalt, and construction materials are given in the 104-page catalog for 1955 from *Soiltest Inc.* Included are laboratory layouts and equipment lists.

(36) LONG ARMS FOR TRACTORS: Showing maximum spans, line speeds, and capacities, *Sauerman Bros.'* bulletin 160 gives scraper and slackline bucket sizes for tractors from 40 to 150 hp. Tractor-powered Sauerman scraper machines can work in places that do not allow the headroom other machines require, as well as over surfaces that will not support their weight.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after June 15, 1955—if mailed in U. S. or Canada.

Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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51	52	53	54	55	56	57	58	59	60
61	62	63	Students should write direct to manufacturer.						

Name_____ Title_____

Company_____

Street_____

City and Zone_____ State_____

(37) FROTH FLOTATION: "Mineral Dressing Notes" No. 21 available from the mineral dressing dept., *American Cyanamid Co.* is a concise, authoritative study of flotation from its early history to present-day chemistry and applications. It has an extensive bibliography.

(38) COMPRESSORS: Bulletin 201-C from *Pennsylvania Pump & Compressor Co.* lists horizontal, single-stage compressors, available in sizes from 10 to 125 hp and for pressures up to 150 psi gage. Air Cushion valve equipment is termed "unique in the complete absence of bolts or screws."

(39) SEPARATOR: Bulletin from *Ore & Chemical Corp.* on the OCC Heavy-Media separatory vessel, suitable for all types of minerals and coal, states that "there is no need for complicated, giant-size machines operating with high power consumption." Among features emphasized are easy installation, easy operation, and the fact that the elevation of separated products is substantially the same as the feed elevation, thereby simplifying product handling problems.

(40) FILTER MEDIA: *Porous Plastic Filter Co.'s* bulletin T-115 contains performance data on porous Teflon filter media and information on complete filter units using this newly developed fluorocarbon material.

(41) CONTINUOUS WEIGHING: *Minneapolis-Honeywell Regulator Co.'s* data sheet 11.5-3 on continuous weighing meters describes the Massometer, designed for flow-rate measurements of free-flowing solids, and Merchen scale meter, which provides continuous belt weighing.

(42) HOSE CHECK LIST: An 11-point check list from *Thermoid Co.* highlights four common abuses of hose with drawings. Cardboard chart is to be hung on plant wall as a reminder that hose, although rugged, can be damaged by abuse.

(43) WASTES TREATMENT: *Hardinge Co.* has bulletin 35-D on water sewage and trade-waste treatment equipment. The 20 pages contain drawings, photographs, and specifications on flocculating units, clarifiers, digesters, filters, and other equipment.

(44) DIESELS: "Power for Progress" describes the operation of *General Motors* 6-110 series diesel engines and illustrates industrial and mine models in the series from 200

to 575 hp. Brochure covers design features, specifications, and power curves of single, multiple-engine and torque converter units and includes photos of these engines at work in various types of equipment.

(45) SHOVELS: Bulletin X-156 from *Harnischfeger Corp.* covers the Magnetorque hoist drive for P&H shovels. The A-to-Z story of Magnetorque is told with keyed cutaway drawings, a schematic comparison with adjustable voltage systems, a comparison chart that pictures bail pull and bail speed of the different systems, and on-the-job photographs.

(46) ANALYTICAL BALANCES: *Fisher Scientific's* 8-page illustrated bulletin gives the theory and operation of "the fastest analytic balances in the world." Section is devoted to Micro Gram-atic balance, single-pan constant-sensitivity balance with an accuracy of ±0.002 mg, said to require one third to one quarter the time of conventional micro balances.

(47) SUPER REFRACTORIES: *Carborundum Co.* has a 24-page booklet giving the latest physical and chemical properties on super refractories. Data is assembled in easy-to-find style and augmented by lists of applications together with pertinent charts and tables.

(48) WIRE ROPE: *Bethlehem Steel Co.'s* "Handling and Care of Wire Rope" is an excellent guide to longer and more useful life of wire rope in practically any kind of service. Included are a list of common causes of wire rope abuse, a check list of conditions to avoid, drum and reel capacities, etc.

(49) ELECTRICAL CONNECTORS: A ¾ turn of couplings fully engages connector in *Joy Mfg. Co.'s* Quik-Lok series of attachable electric plugs and receptacles for mining requirements. Available for ac or dc, from 35 to 450 a (i.e., No. 8 through 750 mcm, awg), they are factory-molded of flame-resistant Neoprene compound, equipped with corrosion-proof couplings or mounting shells, and are watertight, distortion-resistant, and shatterproof.

(50) MINING EQUIPMENT: *Copco Pacific Ltd.* illustrates its complete line in a 12-page booklet. Product coverage ranges from Copco's well-known rock drills to new Atlas all-purpose hoists. Details and photographs are given for the first time on the 13-model series of Atlas compressors, including the NT-9-MV portable with diesel air-cooled motor.

(51) HYDRAULIC DRILL JUMBOS: *Gardner-Denver's* bulletin J-100 presents straight and offset hydraulic booms, hydraulic lift and swing cylinders, and hydraulic pumps for mounting on any suitable chassis or vehicle. Also shown are completely equipped hydraulic drill jumbos for rail service, the self-propelled G-D Mobiljumbo with remote drill controls, roof-pinning jumbos, and tractor-mounted jumbo units complete with air compressor.

(52) TRACTORS: A 28-page folder in color illustrates features of the 208 hp rubber-tired tractor built by *LeTourneau-Westinghouse Co.* Photos, diagrams, and charts show how the unit's range of speed cuts minutes from the work cycle and reasons why the machine requires low maintenance and few repairs.

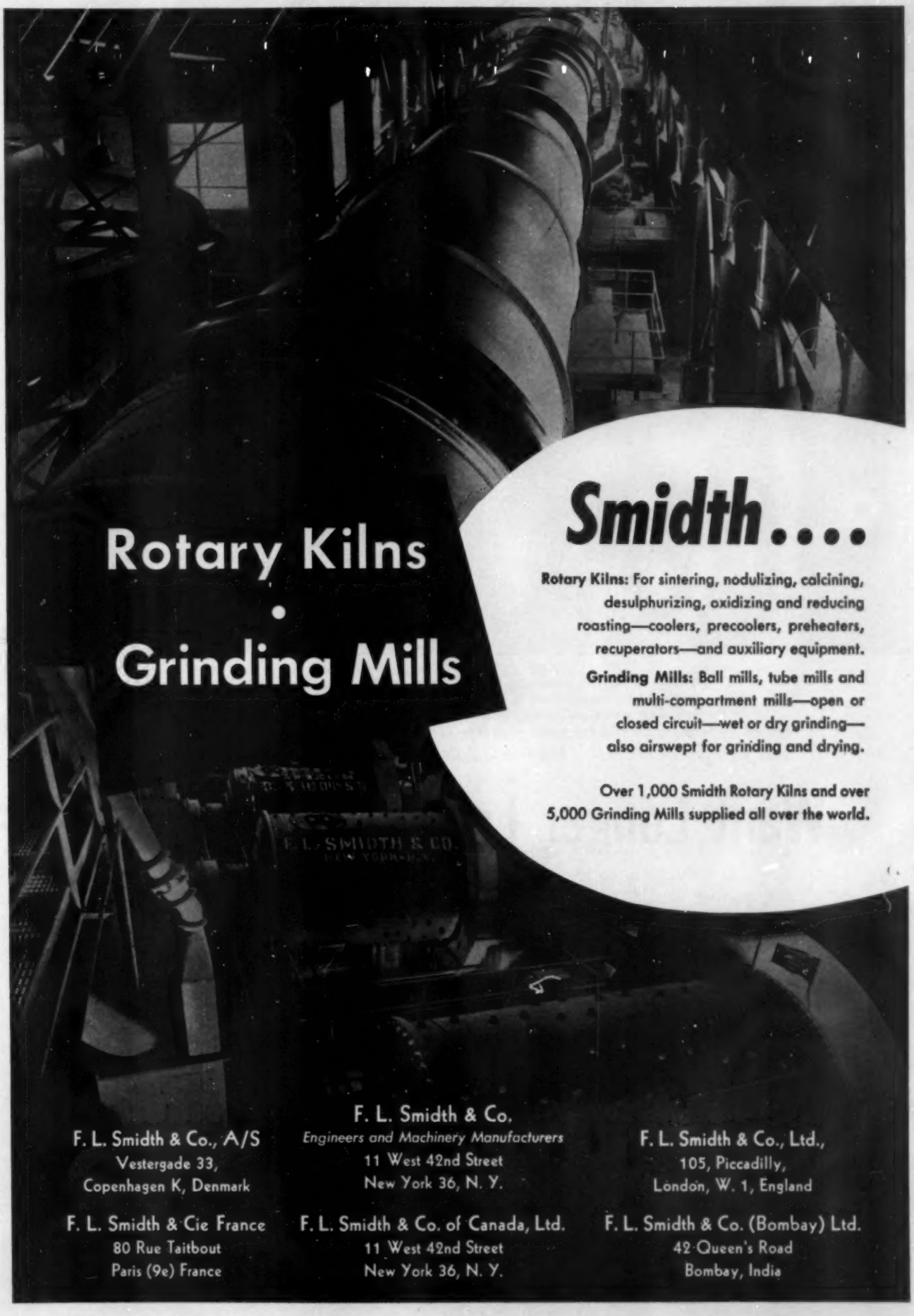
BENEFICIATION NEWS: For *Denver Equipment Co.'s* item 323 described on page 208 circle **(53)**. For item 324 circle **(54)**; item 325 circle **(55)**. For items on opposite page, circle **(56)** for 321; **(57)** for 322; **(58)** for 327; **(59)** for 326; **(60)** for 328.

A limited number of reprints of the following articles from MINING ENGINEERING are available.

(61) "Taconite Beneficiation Comes of Age at Reserve's Babbitt Plant," by Oscar Lee.

(62) "Leach for Lynn Lake Ni-Cu-Co Sulphides."

(63) "Orientation of Cube Diamonds in Drill Bits," by Eugene P. Pfleider.



Rotary Kilns • Grinding Mills

Smidth....

Rotary Kilns: For sintering, nodulizing, calcining, desulphurizing, oxidizing and reducing roasting—coolers, precoolers, preheaters, recuperators—and auxiliary equipment.

Grinding Mills: Ball mills, tube mills and multi-compartment mills—open or closed circuit—wet or dry grinding—also airswept for grinding and drying.

Over 1,000 Smidth Rotary Kilns and over 5,000 Grinding Mills supplied all over the world.

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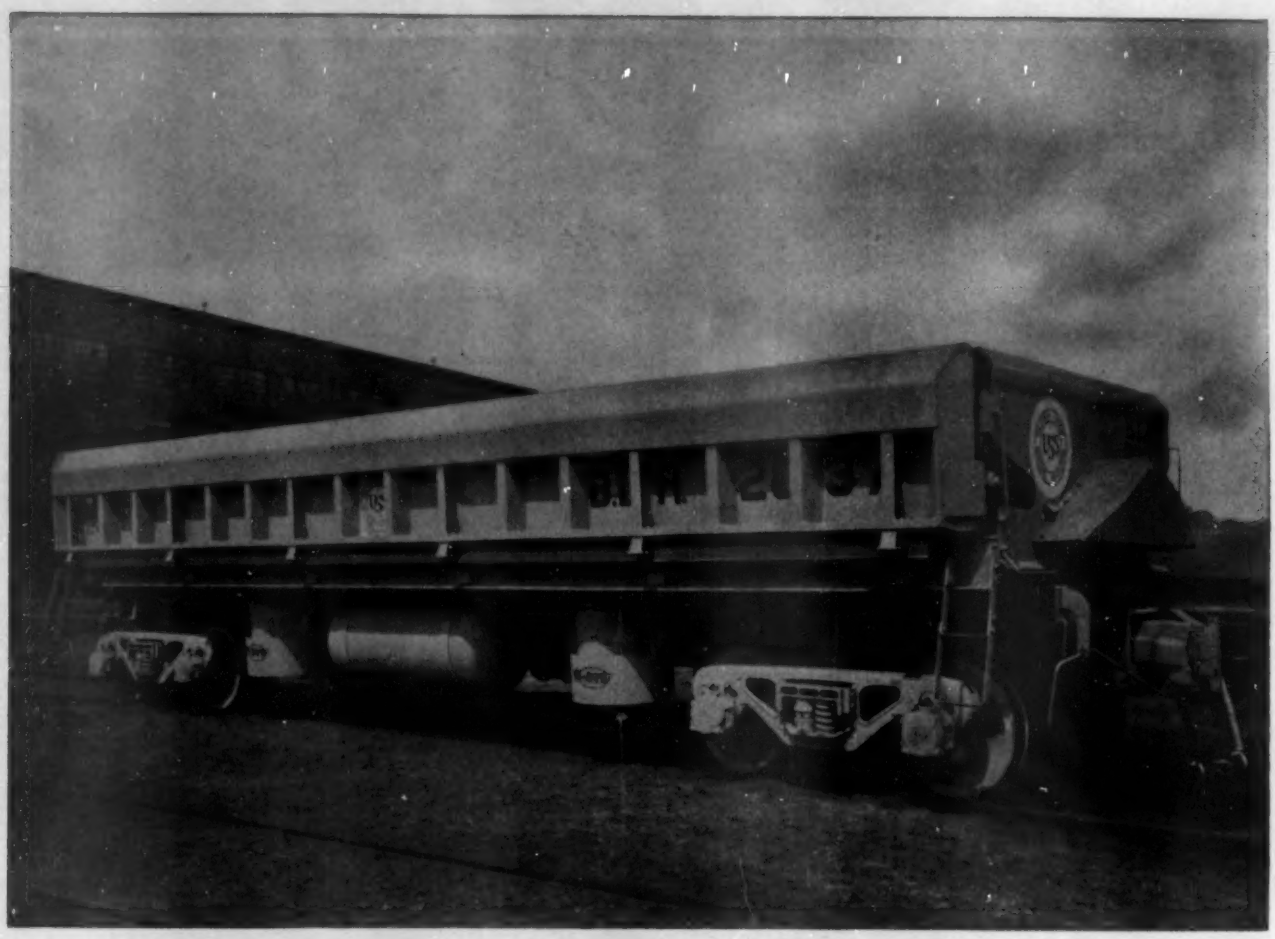


Stands the Gaff. Increase the life of your mine car bodies by designing them to utilize high strength, low alloy steels containing nickel. The car body shown here is one made from TRI-TEN steel, a product of United States Steel Corp., Pittsburgh, Pa. TRI-TEN steel is widely used to meet demands for ruggedness and strength where minimum weight is also a requirement.

Want Longer Lasting Ore Cars?

Bodies withstand impact, abrasion and corrosion when made of high strength, low alloy nickel steels

DON'T INCREASE SECTION THICKNESS to lengthen life of ore car bodies...

Don't add deadweight to strengthen them, even where battering and corrosion now breed maintenance problems...

Increase car life, and at the same time cut maintenance, by utilizing high strength, low alloy steels containing nickel.

These steels give you 50% greater yield point than structural carbon steel. Especially important, they retain a high degree of their original strength during years of use because the resistance they offer to atmospheric corrosion is three times that offered by carbon steel.

In addition, low alloy nickel steels distinctly excel structural carbon steels in resisting impact, wear and abrasion.

Take full advantage of the properties these low alloy nickel steels offer you.

Every mine operator should have a copy of "Nickel-Copper High-Strength, Low-Alloy Steels." It discusses design factors that help you cut weight. It explains why these nickel alloy steels provide superior resistance to atmospheric and many other types of corrosion. It describes their behavior in fabrication.

Write for your copy now. INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Copper Woes Bring Action

The U. S. Government banned all exports of domestically refined copper during February and March and set an export limit of 12,000 tons on copper scrap and copper-alloy scrap. The ban reflects the continuing shortage of copper. Foreign consumers of copper, cut off from normal supplies by long strikes in Northern Rhodesian mines, have been attempting to obtain what they need from U. S. sellers. There has been no letup in domestic demand for copper, with custom smelters stating that they are sold out for the next few months and producer situation is similar.

Shhhh!

A recent letter from the Atomic Energy Commission in Washington, D. C., to uranium ore producers and shippers advised caution in discussion of reserves and shipments. However, the Grand Junction office of the Raw Materials Div. said: "We are not ordering anyone not to tell stockholders and so forth how much ore is in reserves or what shipments are. The letter was sent out by Washington and not us."

Plant Expansion

The Potash Div. of International Minerals & Chemical Corp. completed a $2 million expansion and modernization program at its Niagara Falls, N. Y., plant. Begun two years ago, expansion raised capacity of the basic chlorine caustic potash plant to 25 tpd of chlorine, an increase of 25 pct, and doubled capacity for liquid caustic potash and potassium carbonate. Also added was a new unit which will produce 60 tpd of 20° Baumé hydrochloric acid. Expansion in the liquid caustic evaporation plant was designed to allow for further increase in basic plant capacity to 40 tpd of chlorine.

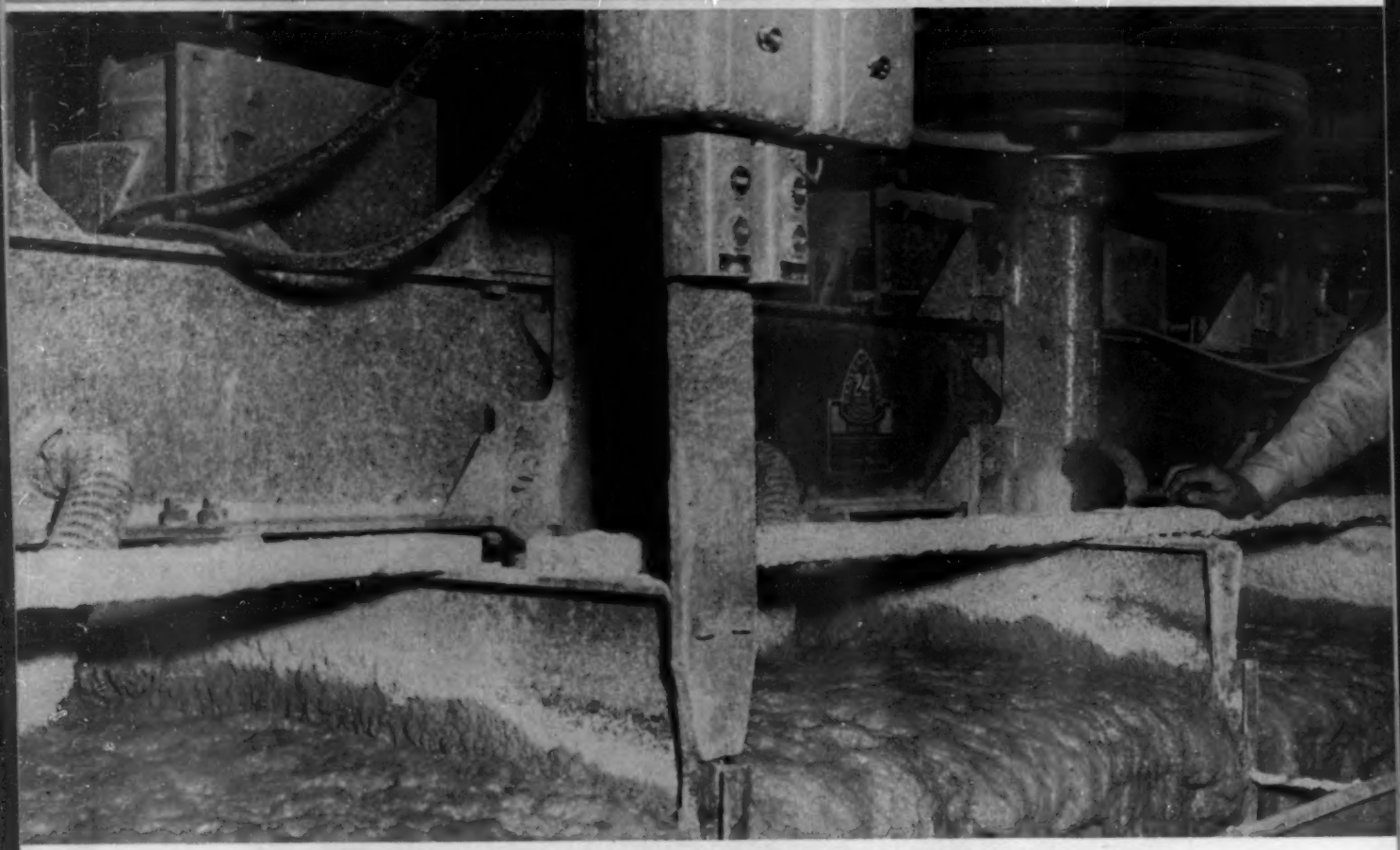
Anaconda Uranium Grows Bigger

New units now under construction at the Bluewater, N. M., uranium mill of Anaconda Copper Mining Co. should be completed this year. This is the second major uranium mill expansion there. The new AEC contract, signed last September, calls for enlargement of the acid leaching circuit during construction. Reason for the expansion is said to be the discovery and delimitation of increased tonnages of sandstone ore on the Laguna Indian Reservation. While the expansion is planned basically for Anaconda ore, the new units will also process ore purchased by the AEC Bluewater Receiving Depot.

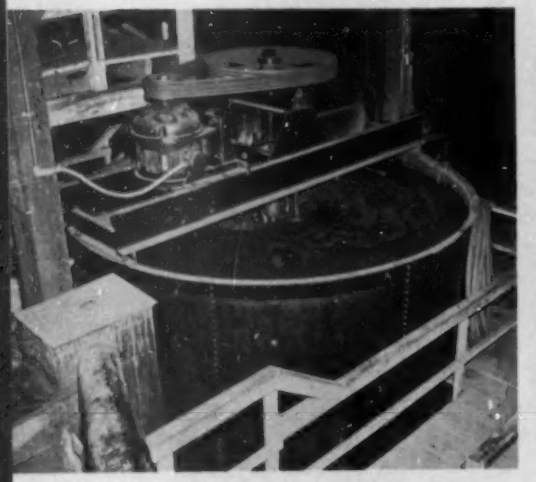
Senate Investigation

Following a meeting of the Senate Interior and Insular Affairs Committee, Chairman Murray (D-Mont.) announced that an investigation of the stockpiling program will be undertaken to determine its effectiveness in aiding the domestic mining industry. The investigation will be under the auspices of a subcommittee on minerals, materials, and fuels. The group will be a successor to the one headed by Senator Malone (R-Nev.) during the last congress. Membership will include Democrats Long (La.), O'Mahoney (Wyo.), and Scott (N. C.) and Republicans Malone, Dworshak (Idaho), and Barrett (Wyo.).

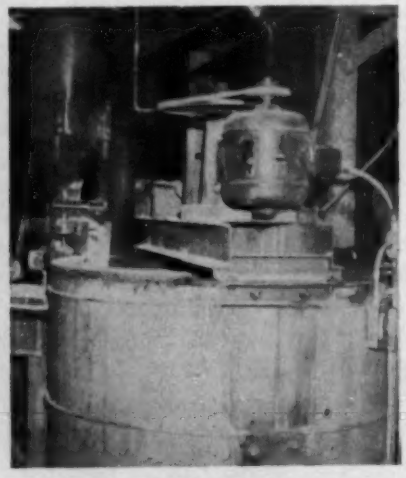
DENVER EQUIPMENT



This 8 cell No. 24 (43x43) DENVER "Sub-A" Super Rougher Flotation Machine, including installation, paid for itself in less than two months! In June, 1954, this machine was installed at the Glen, Mont., tungsten (scheelite) operation of Minerals Engineering Co. as a scavenger to reduce flotation tailings loss. Treating 333 T/24 hr., tailings were assaying .0577% WO_3. After installing the 8 cell No. 24 DENVER "Sub-A" Super Rougher Flotation Machine, tonnage was increased and tailings assays were immediately lowered to .0516% WO_3. This amounted to



Thorough dispersion of reagents prior to flotation is accomplished by this 12'x12' DENVER (Patented) Super Agitator and Conditioner. Patented standpipe gives positive recirculation of pulp in conditioning cycle, insures intimate reagent contact with pulp particles and higher flotation efficiency. Item No. 323.



When the DENVER Cone Type Dry Reagent Feeder is used to feed dry reagents to a DENVER Conditioner, as pictured above, it can be readily mounted to feed directly into the tank, where efficient dispersion of the reagent and pulp is affected. Feed is easily and accurately controlled. Write for Item No. 324.

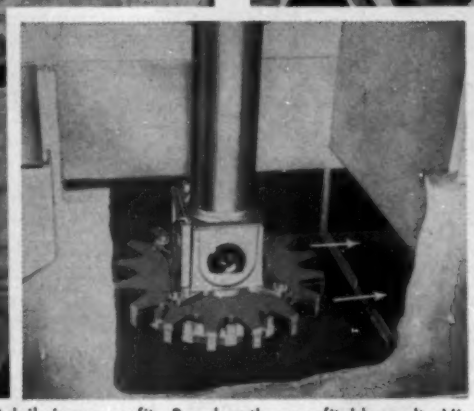
This is the new DENVER Reagent Feeder. Most important new feature is a special inlet float valve so reagents can be easily piped into feeder from a storage drum. Also, two other improvements include a new, precision Hand Wheel adjustment for micrometer accuracy, and a calibrated feed indicator. Write for Item No. 325.

"The firm that makes its friends happier, healthier and wealthier"

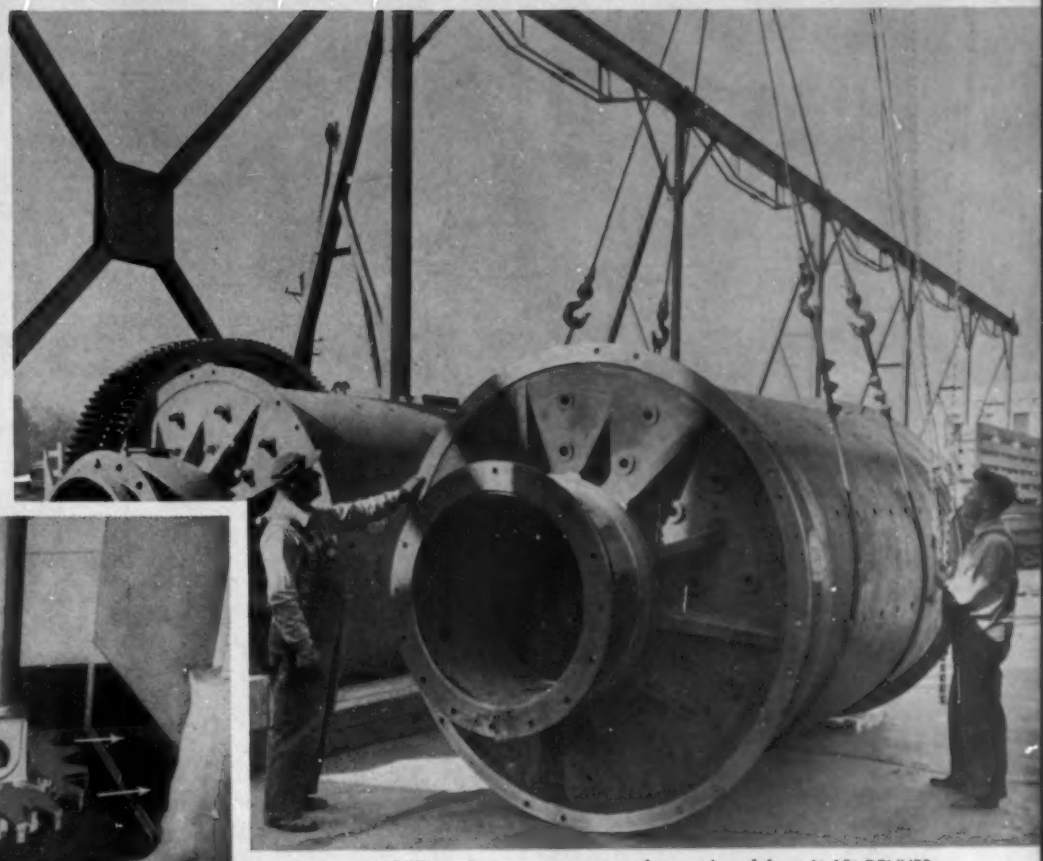
DENVER EQUIPMENT COMPANY

1400 17TH STREET DENVER 17, COLORADO

IN THE NEWS . . .



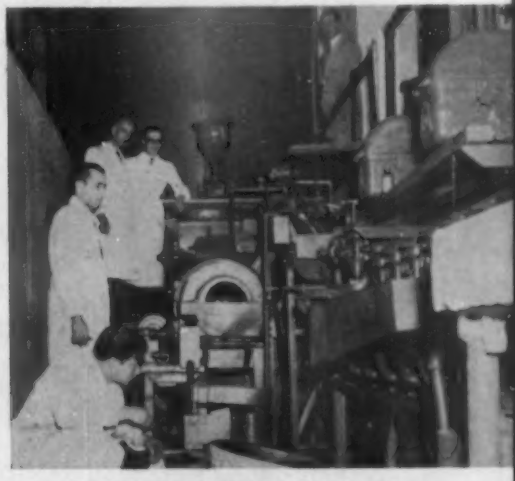
about $300 daily in new profits. Based on these profitable results, Minerals Engineering Co. decided to increase their plant capacity to 600 T/24 hrs. Three additional 4 cell No. 24 DENVER "Sub-A" Super Rougher Flotation Machines are being installed in the new roughing and scavenging circuits. Write for Item No. 321.



DECO machinists prepare two of an order of four 6'x10' DENVER Steel Head Mills for shipment to Spain for use in a 600 T/24 hrs. Cyanidation plant. Each mill is equipped with manganese liners, small diameter trunnion overflow and 125 hp. motors (due to light grinding medium). They are following the African practice of using silica grinding media, rather than forged steel grinding balls. (Each mill will operate in closed circuit with a DENVER Rake Classifier.) Item No. 322.

DENVER Disc Filter has patented segment that gives drier cake by using gravity drainage as well as vacuum. Complete removal of filtrate prevents "blow-back." This 6'-8 disc DENVER Disc Filter is used to reduced zinc flotation concentrates from 30% solids in filter feed to 8% moisture in cake. Write for Item No. 327.

DENVER Equipment Co. bulletins on DENVER Jaw Crushers, DENVER-Dillon Screens and DENVER SRL Sand Pumps contain details on construction, capacities, operating features, related tables and data. If you have not received one through the mail, write for your copies at once. Write for Item No. 326.



The Colombia National University, Bogota, Colombia, Mineral Pilot Plant was designed and equipped by DECO. It includes complete facilities for selective flotation and gold-cyanide leaching pilot mill and testing work. Technicians were trained in the DECO Laboratory, Denver. For tests and equipment, Item 328.

WRITE TODAY, FOR ADDITIONAL INFORMATION . . . Please request additional information by the Item Number.

COLORADO SPRINGS, 500 South Sawatch Street, Phone MElrose 3-7180
DENVER 17, Box 5268, 1400 17th Street, Cable DECO, Phone CHerry 4-4466.
CHICAGO 1, Bell Building, CEntral 6-2423.
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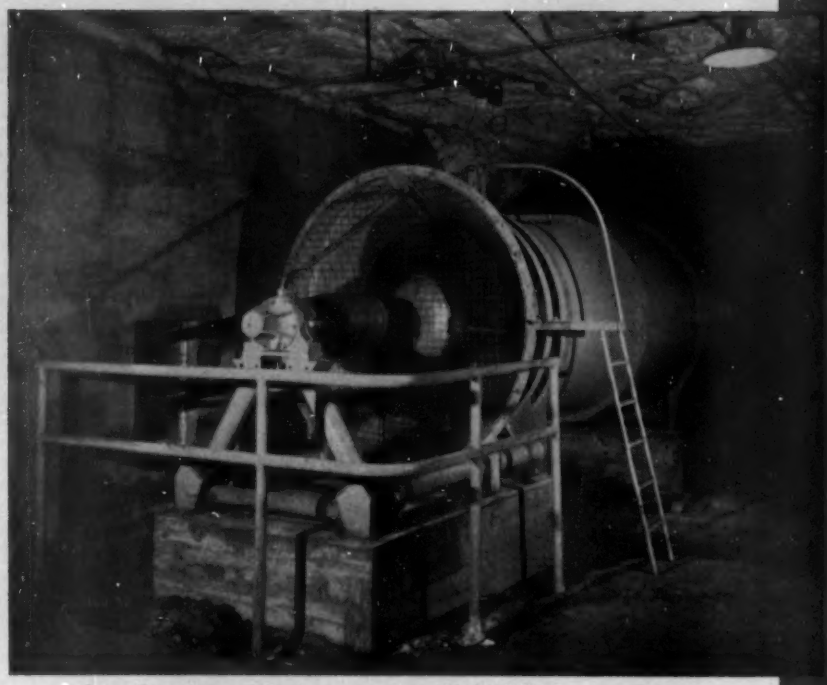
A JEFFREY FAN FOR EVERY MINE JOB . . .



for heavy duty up to 13" W.G. pressure

This western mine installation is the 12A Series AERODYNE — a 12-blade, self-contained deluxe fan designed for maximum pressure of 13" W.G. and volumes from 20,000 to 700,000 C.F.M. Features include individual, positive blade adjustment and custom-made pillow block which has internal circulating oil lubrication, with ample radial loaded spherical roller bearings and separate end thrust ball bearing. For heavy duty, Jeffrey also builds the most popular mine fan in America, the 8H Series AERODYNE. The 8H can blow or exhaust from 20,000 to 500,000 C.F.M. of air at pressure up to 20" W.G.

for medium duty up to 5" W.G. pressure

Economy and efficiency are combined in the Jeffrey 6F Series AERODYNE engineered for medium duty general mine ventilation. Six universally adjustable blades made of cast-aluminum alloy give the 6F wide adaptation to changing conditions. Another low cost fan for intermediate duty is the Jeffrey AERODYNE Jr., with capacity of 5,000 to 150,000 C.F.M. up to 4" W.G. pressure.

for ventilating single drifts

In exploration mining no fan beats the Jeffrey 5 H.P. AERODYNE Midget for blowing or exhaust through tubing. This sturdy, self-contained fan has free delivery volume of 6200 C.F.M., 6.5" Maximum Static Pressure. It's a low-height, light-weight unit, easily portable from place to place. Also for light duty ventilation: Jeffrey 1½ H.P. Midget Blowers, Type 61 Blowers and Universal Blowers.

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IF IT'S MINED, PROCESSED OR MOVED . . . IT'S A JOB FOR JEFFREY!

Anaconda First to Roast Low Grade Sulfur Ore to produce SO_2 for Acid Manufacture

The world's first commercial installation for producing SO_2 gas from low grade sulfur ore, is now on stream at Anaconda Copper Company's plant at Weed Heights, Nevada.

The FluoSolids System that makes this possible includes four 18 ft. dia. Reactors plus other Dorr-Oliver and auxiliary equipment. SO_2 gas is sent to a 450 TPD contact acid plant which supplies all acid requirements for leaching 11,000 tons of copper ore per day.

Feed to the system is 650 to 750 tons per day and gas production 26,000 to 30,000 C.F.M. Gas strength averages 8 to 12% representing a sulfur recovery of 98%. Unusual? Yes, because this is the first time that low grade sulfur ore could be recovered as SO_2 . . . economically. Here's how the system works . . . ore averaging 28% total sulfur is crushed to 10 mesh and fed dry to the Reactors which operate in parallel. Once ignition temperature is reached no extraneous fuel is needed. Ore is simply fed in at the design rate, latent heat in the bed immediately brings it to ignition temperature, and the fluidizing air oxidizes the sulfur to SO_2. Shutting down is a matter of minutes. And because the fluid bed stores sufficient heat, roasting can be started again after as much as 72 hours without adding additional fuel.

If you would like more information of FluoSolids . . . the most significant advance in roasting technique in the last 30 years . . . write Dorr-Oliver Inc., Stamford, Conn., or *in Canada*, Dorr-Oliver Inc., 26 St. Clair Avenue, East, Toronto 5.

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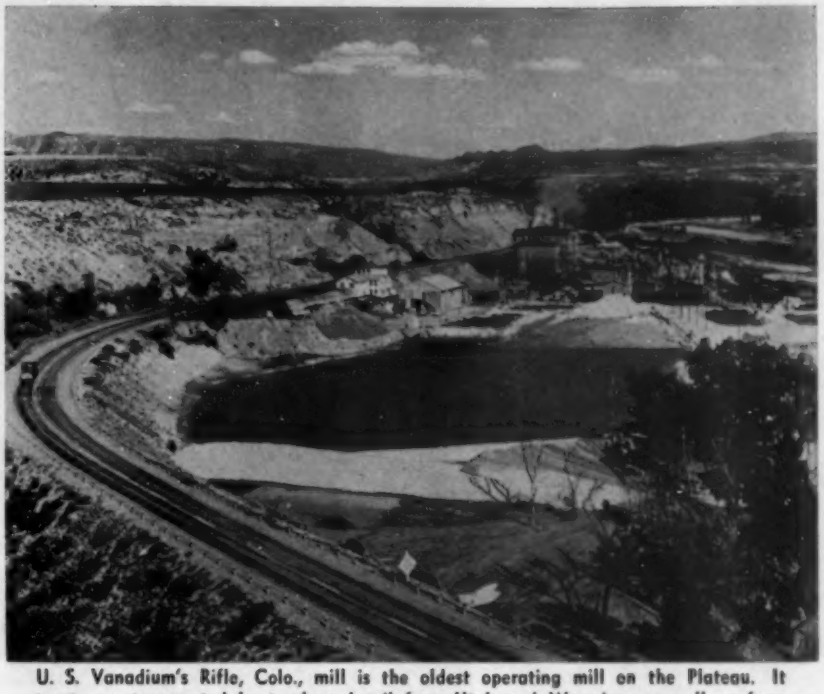
Colorado Plateau Revisited — Men, Mines And Machines in Continuous Upsurge

Two years ago the Colorado Plateau boasted some 200 uranium mines. Today, the number has jumped to 600, with about 3000 people engaged in working the properties. All told, nearly 10,000 people earn their living on the Plateau in the mining and refining of uranium ores.

In two years expenditures for this phase of the nation's atomic energy program jumped from $30 million to $100 million per year. Thousands of amateur and professional prospectors and at least 1500 trained geologists and mining engineers have poured into the colorful and rugged Plateau area.

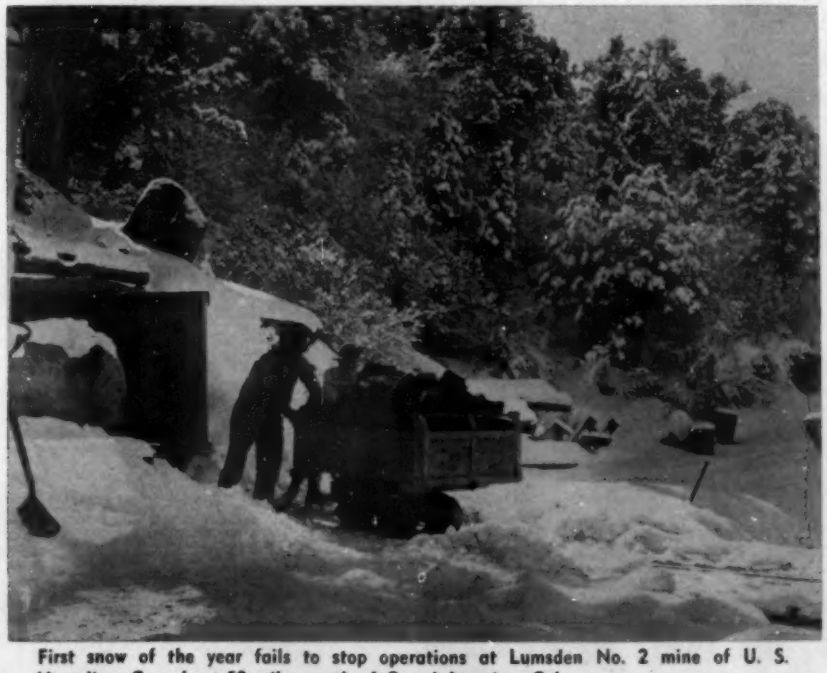
Two years ago only 250 persons were engaged in drilling. Today, about 1000 persons are involved in drilling uranium claims. Private mining companies are spending $5 million a year on drilling. There, drilling efforts have gone from 2 million to 3½ million ft a year. U. S. Vanadium Co., one of the earliest operators on the Colorado Plateau, last year employed as many as seven different contract drilling firms to do its exploratory work.

Most of the uranium mining operations on the Plateau are small, since orebodies have still proven to be spotty. U. S. Vanadium and other companies have been following the practice of farming out the work on their properties to a large number of independent contractors. Free enterprise and the individual operators are a big thing on the Plateau.



U. S. Vanadium's Rifle, Colo., mill is the oldest operating mill on the Plateau. It treats ore transported by truck and rail from Utah and Wyoming, as well as from southern Mesa County in Colorado.

Almost all trucking is done by small contractors. About 300 people are engaged in the business of hauling ore and supplies to and from the mines and mills in the area. The number of ore trucks increased from 100 to 200 in the past two years; supply trucks from 50 to 75. Even on the desolate looking roads of the mesa it's not unusual for several trucks to pass each other within a few minutes. Truckers often make two trips a day over several hundred miles of rough terrain, tooling vehicles up the sides of steep cliffs on roads no wider than the old wagon trails.



First snow of the year fails to stop operations at Lumsden No. 2 mine of U. S. Vanadium Co., about 50 miles south of Grand Junction, Colo.

Nine mills treat ore on the Plateau, with more than 2000 people employed. This doubles the number on the payrolls two years ago. Both U. S. Vanadium mills, at Uravan and Rifle, Colo., have expanded considerably since 1952. They treat ore from mines in Utah, Wyoming, and of course, Colorado. Other mills are located at Durango, Grand Junction, and Naturita, Colo.; Monticello and Salt Lake City, Utah; and Shiprock and Grants, N. M.

Grand Junction is the focal point for the Plateau's activities. Here, the Raw Materials Div. of the Atomic Energy Commission makes its western U. S. headquarters. Peach growing used to be the main money maker around Grand Junction. Uranium is bringing in about ten times the amount that peaches bring now.

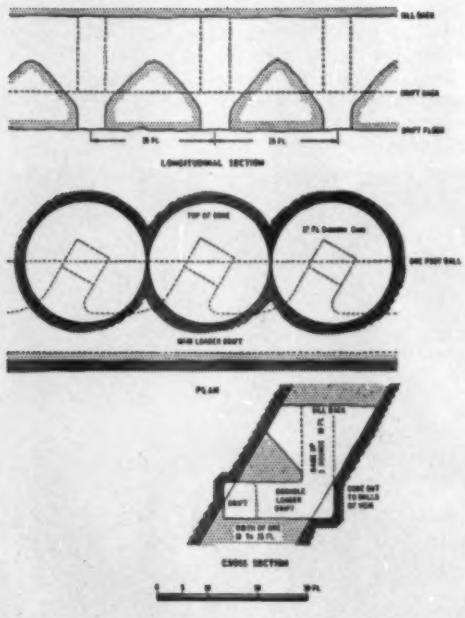
INCREASE PRODUCTION LOWER COSTS

Yes! You can increase production and lower costs by using Eimco loaders to load your production tonnage.

The advantages of being able to load larger pieces, use less powder, practically eliminate secondary blasting and absolutely eliminate expensive chutes and grizzlies, will enable your mine to get into production in a new area faster at less expense.

That's why so many mining men are traveling to see mines that have changed their systems to production loading with Eimcos.

Many different ideas for saving time and lowering costs have been developed by operators to fit their particular conditions. A sketch of one of these is at right. Eimco engineers have helped work out numerous systems, they will be glad to help you. Write Eimco for information.



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You Can't Beat An Eimco

Divers Fail in Attempt to Open Valve At Osceola

U. S. Navy and professional divers dropped down under 230 ft of water in the Osceola mine of Calumet & Hecla Inc., near Calumet, Mich., in an unsuccessful attempt to open a valve about 140 ft along the 28th level.

If the divers had succeeded, it would have been of tremendous help in the monumental problem of unwatering the reactivated copper producer. The project is the largest of its kind in mining history. When the divers dropped into the shaft they descended into a situation that contained many unknowns despite careful preparation. Millions watched over a nation-wide television hookup as the heavy suited underwater workers slid from sight. Five times the divers went under—each time returning without reaching the valve.

The pipeline to which the valve is affixed runs through a dam, connecting the Osceola lode to the nearby Conglomerate lode. With the valve open, water between the 25th and 28th levels—about 202 million gal—would flow through the pipeline to the Conglomerate lode. From there, it would have been taken out with submersible pumps located in the vertical Tamarack No. 5 shaft which intersects the Conglomerate lode.

When the divers failed to open the valve, engineers were committed to comparatively slow pumping operations in the inclined Osceola No. 13 shaft, using specially constructed incline submersible pumps.

One diving try was made by two Chicago firms, while the Navy made four attempts. Navy personnel came from the experimental unit at Washington, D. C. Compressed air was used in three of the dives. For the last two dives the Navy men breathed a helium-oxygen mixture that helps to offset severe medical handicaps encountered at great depths. Water pressure on divers working in the 28th level was 100 psi. Actually, it was the time element that prevented the divers from completing the job. Even with helium-oxygen working time was limited to about 30 min. R. L. McKenzie, Navy diver from Kevin, Mont., came closest, getting 35 ft into the 28th level. When about 100 ft from the valve he had been down some 25 min, with not enough time left. Debris hampered walking and endangered safety and air lines.

Water cascades into the man car as two Navy divers descend to the 28th level. The valve they sought is located 140 ft along the level. One diver got about 35 ft along the way before his time ran out. Pressure on divers was 100 psi. Despite oxygen-helium breathing mixtures, they were unable to stay down long enough to complete the project.

R. L. McKenzie, Navy diver, came the closest to reaching the valve. He is being helped out of his suit by another Navy man, W. C. Hollingsworth. The strain of diving into pitch black waters is visible on McKenzie's face.

All dives were made under the same general plan, with two divers at a time descending 362 inclined ft from the 25th to the 28th level in a man car designed to protect them from floating debris. There were no sharp corners and the car was heavily weighted with pig iron.

A reel and cable were attached to the front of the man car. In 4 min the car reached the 28th level. One diver walked toward the valve with the cable and another reel. The reel was small enough to fit over the 12 in. valve wheel. The plan called for the diver to crack the valve, place the reel on the valve, and return to the man car. The valve would then be opened after the divers returned to the surface in the man car, tightening the cable. It would have required 26½ turns to open the valve.

The gigantic Osceola unwatering goes on. Work on driving a crosscut from the 24th level in Osceola 13 to the Conglomerate lode began December 16. The distance of about 730 ft was traversed last January.

Exporting 2 Million Tons of Iron Ore A Year From Promising Peruvian Development

Peru's youthful iron ore industry is taking adult strides these days. The South American country, which has long been known for its rich deposits of many other minerals, first saw its iron ore deposits developed early in 1953. Now it is exporting more than 2 million tons a year.

All of the ore comes from a huge open pit mine near Nazca, 341 miles south of Lima. This mine is operated by the Marcona Mining Co., a corporation formed by two North American concerns—Utah Construction Co. and Cyprus Mines Corp.

These rich deposits have an estimated reserve of more than 100 million tons. The ore-body, which covers an area 12 by 19 miles, is on a plateau 2600 ft high, 17 miles from the bay of San Juan, from which the ore is shipped.

Marcona operates the mine under a 30-year contract with the Peruvian Santa Corp., a government entity which started the preliminary development of these deposits. Marcona is required to mine and ship 500,000 tons of ore a year under the contract, but so far has surpassed this and peak production is expected to be several times this amount.

All of the ore is being shipped to steel plants in the U. S., with delivery to Gulf and East Coast ports. An average of 13 Liberty ore ships have been putting into San Juan each month, with each ship taking on 10,000 to 11,000 tons. Ultimately, a portion of the ore will be diverted to the steel plant at Chimbote in northern Peru when it is completed by French interests in mid-1956.

The mine and port personnel now numbers several hundred, with only about 50 of these being Americans. The town of Marcona, located on a hill overlooking the bay, rapidly is becoming a reality. The new community is eventually to include family and single housing, recreation area, school, theatre, market, church, and a 35-bed hospital. Just recently 30 modern housing units were completed for American and Peruvian staff personnel with housing construction continuing at a rapid pace.

This area was so desolate that when Marcona and Utah Construction first moved equipment into the territory in February 1953, they had to use converted wartime landing craft to discharge the units on the beach. Despite the obstacles presented by the "landing" operation, it was carried off in record time. The first load of ore was shipped from San Juan less than three months after the first equipment came ashore, and within 12 months after these machines landed, Marcona had mined and shipped 1 million tons of ore.

Marcona took charge of the mining operation while Utah Construction handled construction of the port works and installation of mining and ore handling equipment. As the overburden was stripped and conveyors and crushers constructed at the mine site, a pier large enough to accommodate ocean-going ore carriers was being built in record time by Pacific Bridge Co. of San Francisco, as a subcontractor for Utah Construction.

Three main pits in the ore-body, which eventually will be connected, are now being worked. The ore mined in each pit is blended together so that not only are contract specifications met, but the most expeditious use of the ore-body is obtained. The ore mined to date has been averaging about 60 pct iron content. Since the ore lies near the surface, the overburden runs from almost nothing to approximately 20 ft. Stripping is by blasting, diesel shovels, draglines, and Caterpillar track-type tractors hauling scrapers. Drilling for the blasting is being done by an Ingersoll-Rand Quarrymaster with a 6-in. bit; a Joy Champion blasthole drill with a 7⅞-in. bit; several Gardner-Denver S-48 sinkers or rock drills, as well as four S-55 hand-held rock drills, a model F-73 hand-held drill and three 3-180's. Timken drill bits are used on these machines. Two 18-ton Manitowoc diesel-powered shovels with

This Manitowoc shovel equipped with a 5½-yd bucket strips overburden at Marcona iron mine, near Nazca, Peru. Overburden ranges from almost nothing to about 20-ft depth.

A diesel-powered shovel loads one of eight 34-ton dump trucks used to transport ore to the crusher. The Caterpillar D8 tractor on the left is used to maintain the ore pit.

A Marcona mine workman cleans up around the hopper leading into the 66x84-in. crusher at the mine. The main conveyor is in the background. The haze is caused by ever-present brown dust around the crusher.

5½-yd buckets are for removal of overburden and ore extraction.

Almost all equipment at the mine is diesel powered. This includes eight Gardner-Denver WBK-500 portable compressors, which are powered by Caterpillar D13000 diesel engines.

The Manitowoc shovels load the ore in eight 34-ton and three 22-ton diesel-powered dump trucks that transport ore to a receiving hopper. Under the hopper is a 7x14-ft reciprocating plate feeder which feeds at the rate of approximately 1500 tph to a manganese grizzly with 6-in. openings. Oversize goes to a 66x84-in. jaw crusher which reduces the ore to 6 or 7 in.

From the crushers, a 60-in. conveyor belt carries the ore upward to an 80-ft screening tower. Here are two 6x10-ft triple-deck vibrating screens of spring-mounted unbalanced type.

From the screening tower the ore is distributed by 36-in. belt conveyors and trippers to a stockpile. Under the pile is a tunnel with gates located every 20 ft. These gates are opened when needed by 42-in. traveling feeders which load a 42-in. reclaiming belt conveyor. This belt emerges from tunnel and conveys the ore to a truck-loading hopper. Here the ore loads the nineteen 300-hp 60-ton highway trucks which haul the ore to the port —27 km away.

All of the electric power for the mine and port operations originally came from Cat D397 diesel-electric sets—three at the mine and three at the port, with larger units now installed at the port to handle the load.

The mine's three-engine generator unit, rated at 325 kva continuous output and 480-v, drives Westinghouse induction motors which power all crushers and conveyors at the mine except for the secondary crusher which is driven by the D337. The machine shops, welding shops, and general lighting for area also use power from these generators.

Arriving at the port area the bottom-dump trucks discharge their load into a concrete receiving hopper. Ore is fed from hopper by a double 48-in. plate feeder to a 42-in. inclined belt which carries ore to the top of port screen tower. Here ore is rescreened and distributed to two conveyors over long storage piles. Ore is reclaimed by traveling 48-in. plate feeder to 48-in. conveyor belt located in tunnel under storage pile. It is transferred to a 42 in. x 1000-ft long deck conveyor that carries ore to the traveling ship-loading gantry.

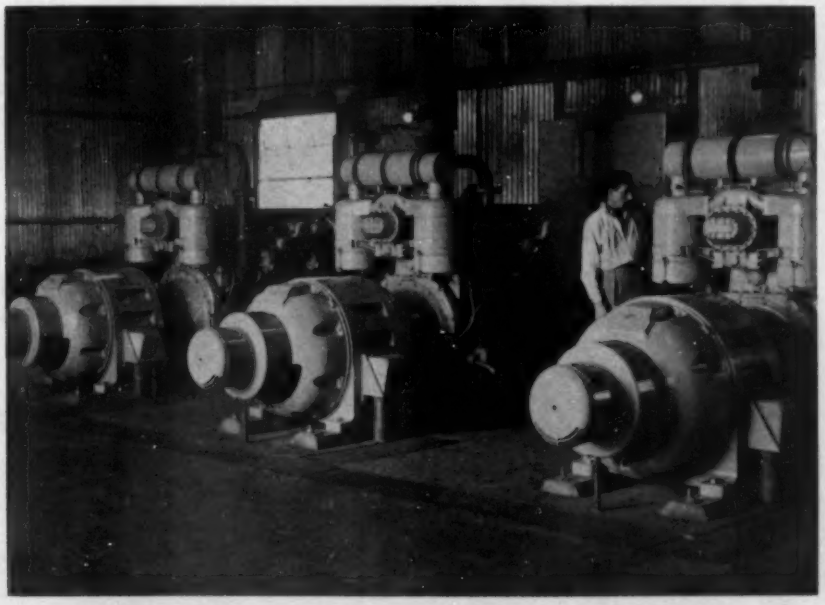
The ore goes by belt up an incline to the boom on the 75-ft gantry. Then another conveyor belt transports it the length of the boom which extends over the ship's hold. Eight to ten hr are required to load a 10,000-ton capacity vessel. The gantry is driven by four electric motors, with only two operating at one time with a total of either 115 hp or 65 hp.

The port electricity generated from three Cat D397 diesel electric sets also furnishes light and power for dock operations.

Marcona keeps a close check on the ore being shipped. Ore samples are analyzed constantly for iron content, sulphur, silica, alumina, and phosphorus by the laboratory located near the pier, which operates 24 hr a day. If samples do not measure up to contract specifications, ore from the stockpile is blended into the load to attain the proper mixture. Laboratory equipment includes a combustion furnace used to determine the sulphur content in ore samples.

A major problem when Marcona first moved in was the complete lack of fresh water at either the mine site or San Juan. At first the water was trucked in from nearby Nazca when the daily requirement was 31,000 gal. Recently, however, a two-unit plant to distill sea water has been completed. This plant has a capacity of 2400 gph and is said to be the only one of its kind in South America.

To provide communication between Lima and San Juan, Marcona built a small runway near the port and operates a five-passenger plane, making three round trips a week.



These three Cat D397 Diesel electric sets provide electric power at the mine. The three-engine unit is rated at 325 kva continuous output and 480 v.

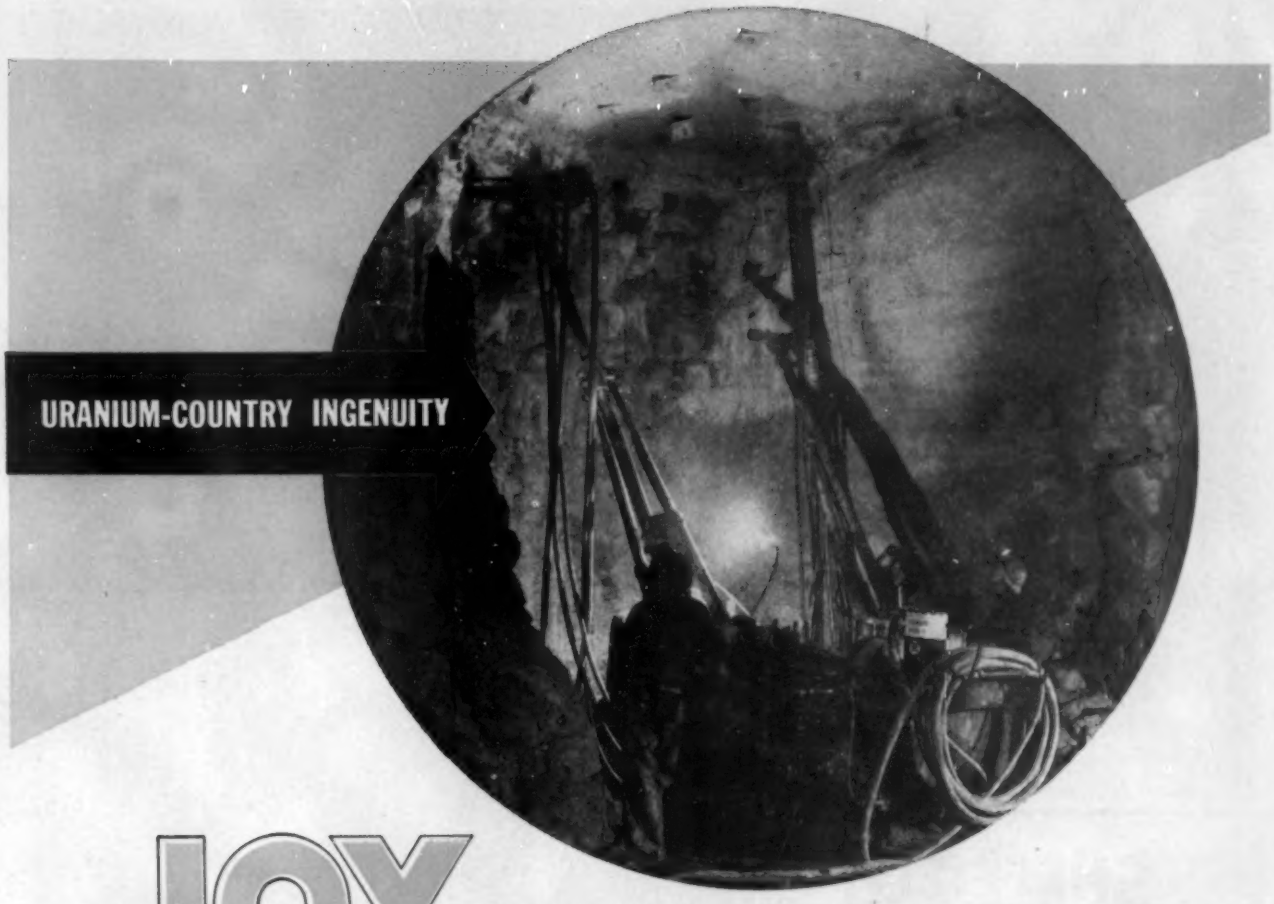
U. S. Mineral Production — 1954

Commodity	Unit	Estimated Production 1953	Estimated Production 1954	1954 Value Thousands of Dollars
Fuels:				
Anthracite	ton	30,949,152	27,000,000	$ 261,000
Bituminous Coal & Lignite	ton	457,290,449	392,000,000	1,889,440
Natural Gas*	million cu ft	8,396,916	8,700,000	870,000
Petroleum (crude)	thous bbl	2,359,998	2,314,000	6,387,000
Nonmetallics:				
Asbestos**	ton	54,456	53,800	4,700
Cement	bbl	264,000,000	267,000,000	710,000
Feldspar	LT	452,600	425,000	4,250
Fluorspar	ton	318,036	235,000	9,500
Graphite	ton	6,281	3,000	90
Gypsum	ton	8,300,000	8,500,000	24,000
Mica (scrap)	ton	73,259	74,000	1,825
(sheet)	lb	849,394	850,000	2,200
Phosphate Rock	LT	12,503,830	12,700,000	77,000
Potash (K_2O)	ton	1,911,891	2,000,000	68,700
Pyrites	LT	922,647	920,000	5,000
Salt	ton	20,789,003	21,000,000	80,000
Sand & Gravel	cu yd	NA	NA	NA
Slate	ton	698,589	710,000	12,750
Stone	ton	NA	NA	NA
Sulphur	LT	5,718,335	5,840,000	155,000
Vermiculite	ton	189,535	200,000	2,600
Metals:				
Aluminum (ore)	LT	1,579,739	1,900,000	16,200
Antimony	ton	372	800	NA
Beryllium	ton	751	615	289
Cobalt	lb	1,775,489	2,290,000	NA
Chromium	ton	58,817	153,000	6,800
Copper	ton	926,448	830,000	493,000
Gold	troy oz	1,704,508	1,602,000	56,070
Iron Ore	LT	117,197,537	78,000,000	527,280
Lead	ton	341,872	317,000	86,000
Manganese	ton	157,536	200,000	15,000
Mercury	76 lb flask	14,337	19,400	5,131
Molybdenum	lb	53,823,235	57,000,000	56,000
Silver	troy oz	37,535,451	37,160,000	33,632
Tin	LT	NA	NA	NA
Titanium (Ilmenite)	ton	513,696	546,500	8,744
Tungsten (60 pct WO_3)	ton	9,605	13,000	43,000
Zinc	ton	547,430	464,000	103,000

* Marketed production
** Canada produces 65 pct of world supply

U. S. MINERAL PRODUCTION 1951-1954

	(Billions of dollars) 1951	1952	1953 (preliminary)	1954 (estimate)
Nonmetallic minerals:				
Fuels	9.8	9.6	10.3	10.0
Other	2.1	2.2	2.3	2.3
Total nonmetallic	11.9	11.8	12.6	12.3
Metals	1.6	1.6	1.8	1.5
Grand Total	13.5	13.4	14.4	13.8



..JOY DRILL JIB/TRACTOR COMBO

CUTS DRILLING COSTS 56¢ A TON!

A uranium mining company made their own Drillmobile by mounting two Joy LM-67 Drills with 6′ chain feeds and Hydro Drill Jibs on a diesel tractor. Result was an 80% reduction in labor costs!

This "Jib-Tractor" drills two faces a shift. Each face consists of 120 to 130 holes, is 18′ wide, 18′ to 20′ high. The Joy extendable Jibs drill horizontal holes up to the 18′ height and slanted holes at 20′.

Drilling speed in sandstone ranged from 30″ to 36″ per minute. Average footage drilled and broken is 7 feet. Ground broken per round is about 150 tons. Previously, air legs and stopers were used for drilling. The table at right illustrates the saving in drilling costs with this new "Jib-Tractor."

Write for Bulletin 87-F to ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

FORMATION	Sandstone
DRIFT SECTION	18′ x 20′
HOLES PER FACE	120 to 130

	Jib-Tractor	Air Legs & Stopers
Rounds drilled per shift	2	½
Tons broken per shift	300	85
Labor cost per shift	$40	$60
Labor cost per ton	14¢	70¢
Saving per ton	56¢	—

Consult a Joy Engineer

for AIR COMPRESSORS, ROCK DRILLS, HOISTS AND SLUSHERS

WAD M 5505

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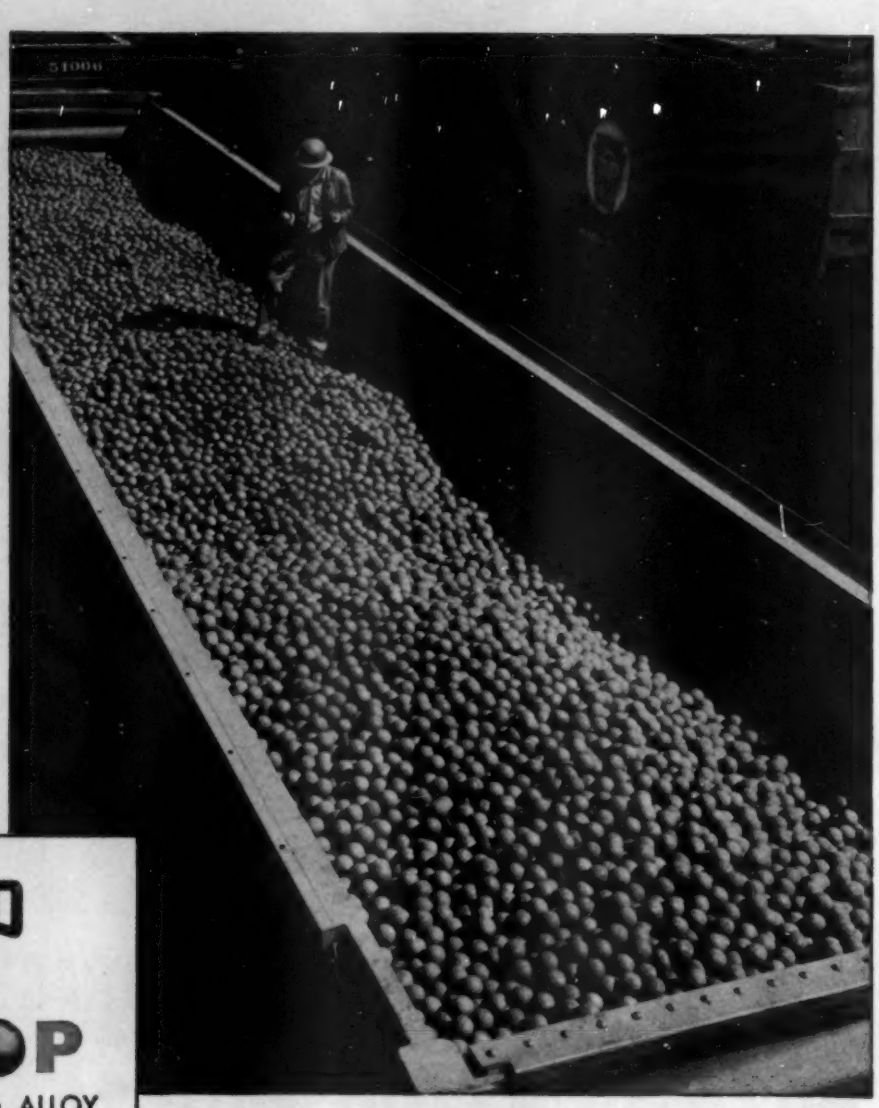
WORLD'S LARGEST MANUFACTURER OF UNDERGROUND MINING EQUIPMENT

Ready to Roll for a Longer Grind



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GRINDING BALLS

This carload of Moly-Cop Grinding Balls might be headed to any one of hundreds of destinations around the world. Sheffield ships them everywhere grinding is part of the industrial picture.

Wherever they go, they'll do a better grinding job. Fewer chargings will be required. Less down time. Less frequent freight bills. Money saved.

That's because Moly-Cop Grinding Balls keep their spherical shape longer. Sheffield's special alloy of steel, copper and molybdenum is just the right "recipe" for longest resistance to wear, chipping and abrasion. There's a big difference in grinding balls—and it will show up on your profit sheet when you use Moly-Cop Grinding Balls.

We're ready with the best grinding ball—plus engineering counsel on how it can best save money in your operation. A call will get you all the facts.

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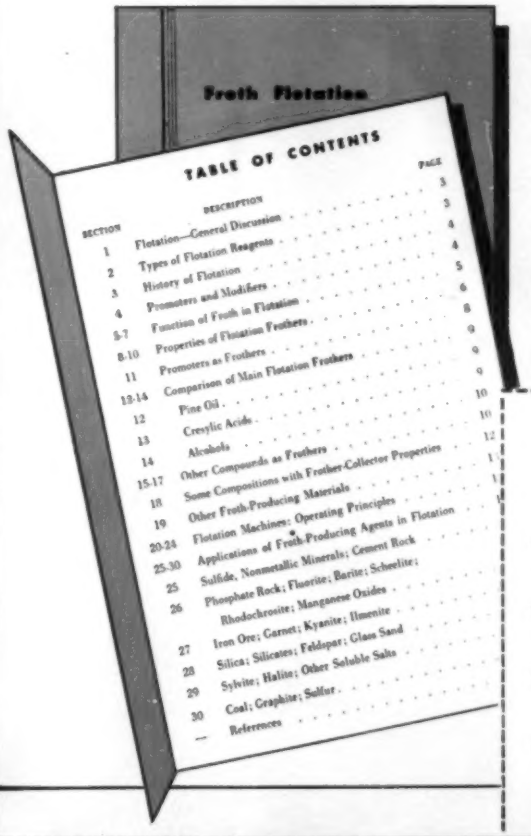

One glance at the Table of Contents tells why this comprehensive, 24-page, current basic summary of froth flotation should be among your everyday reference texts. The extensive bibliography of literature references is in itself invaluable since it lists principal flotation patents as well as technical articles.

Copies of Mineral Dressing Notes #21 were sent to all those on our technical mailing list. But mailing lists are difficult to keep accurate and complete. So, if you have not received your copy, may we suggest that you drop us a note requesting one or use the handy coupon below.

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Mineral Dressing Department
30 Rockefeller Plaza, New York 20

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COMPANY_____

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Cable Address — Limenitro, New York

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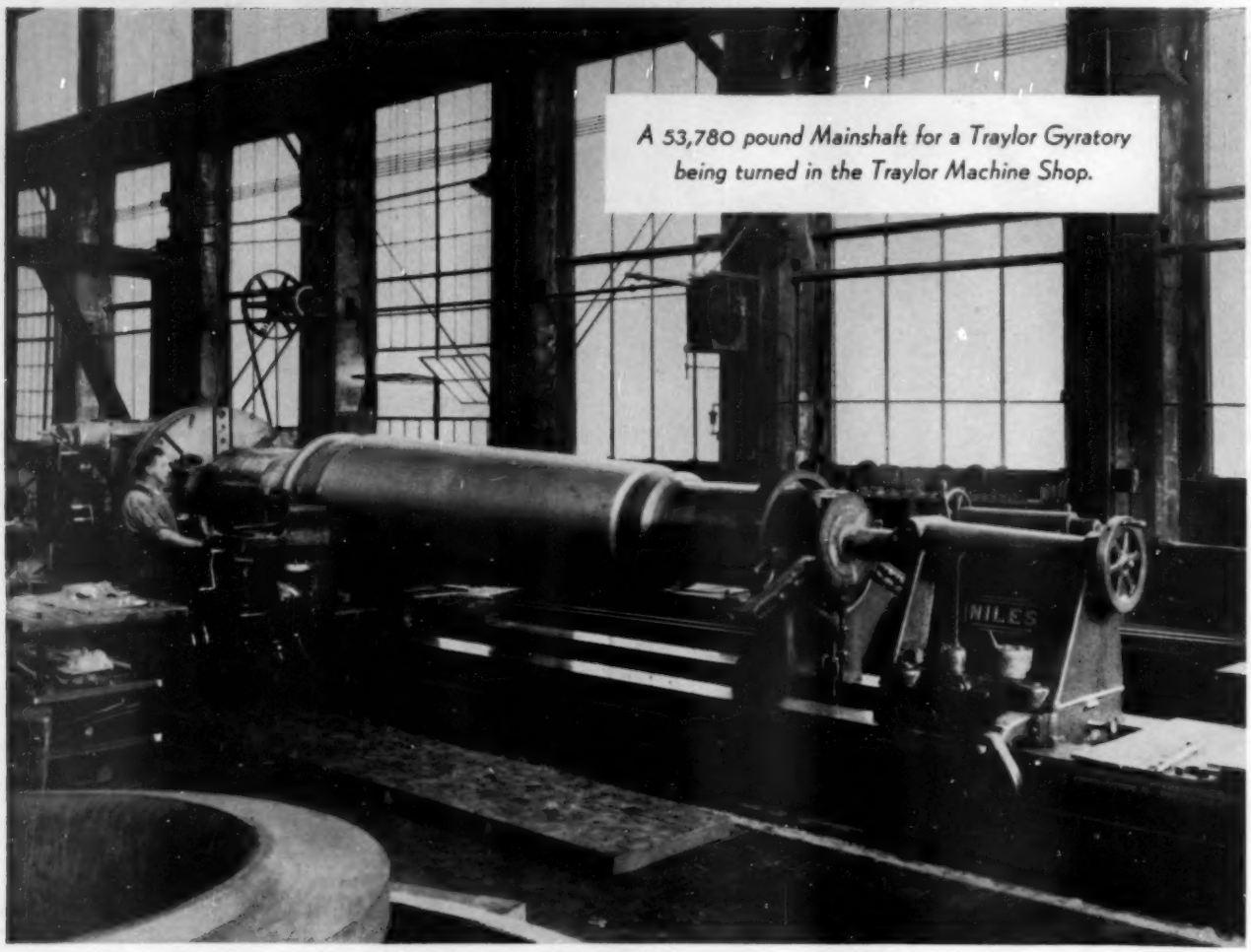

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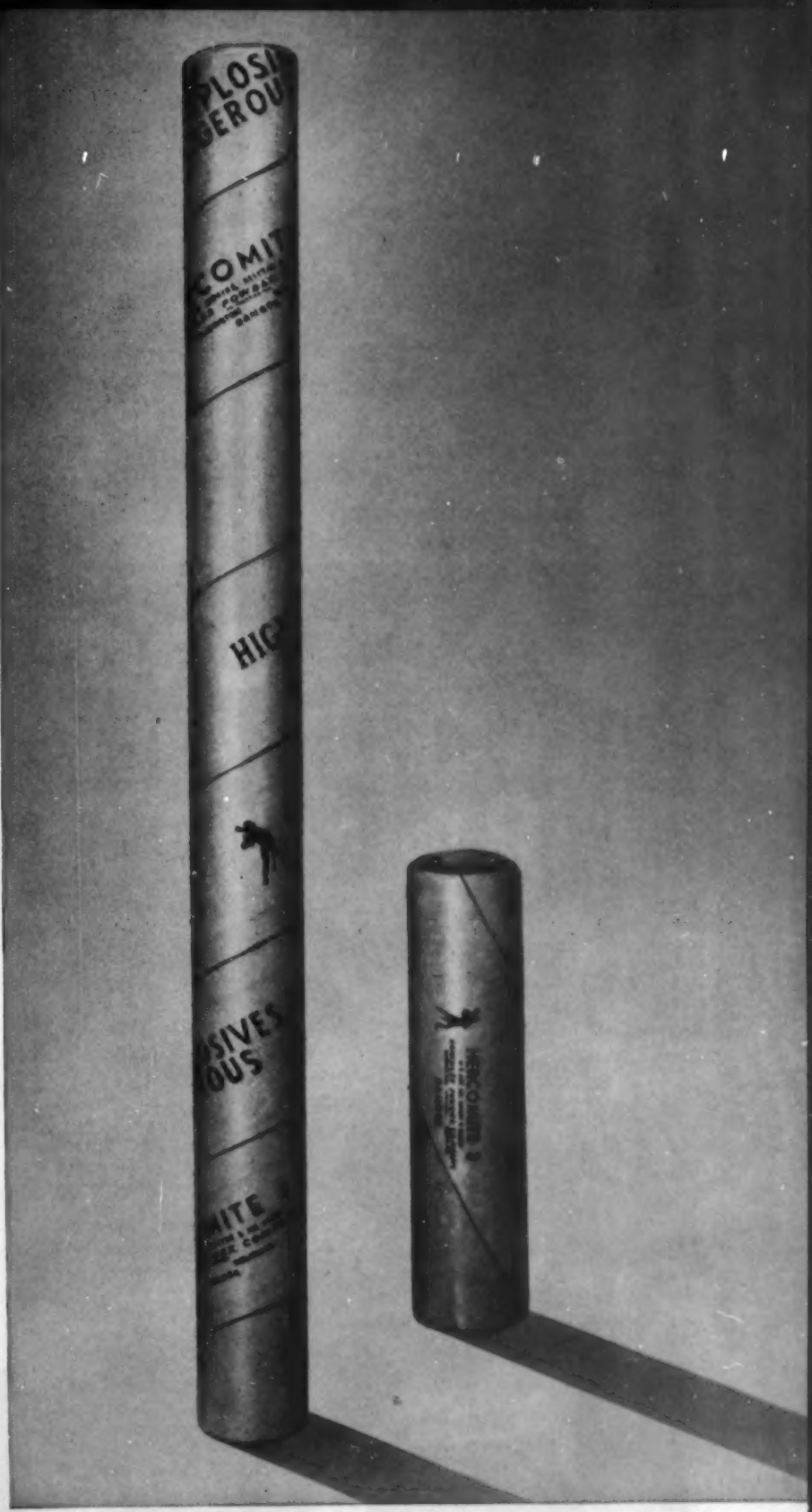
Available in all types of Hercules® dynamite, these long-length, small-diameter cartridges are now in full production.

"King-Size" cartridges make possible a more uniform fragmentation through the discharge of a single column of explosive. Their use means substantial savings in valuable time and labor in loading holes.

Hercules designed, tested, and installed special new packing machines for these "King-Size" cartridges.

Our technical service and sales representatives will be glad to discuss with you how these "King-Size" cartridges can go to work for you.



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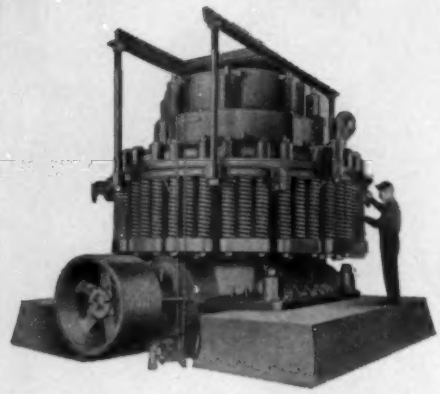

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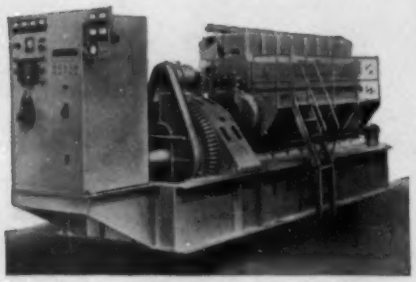

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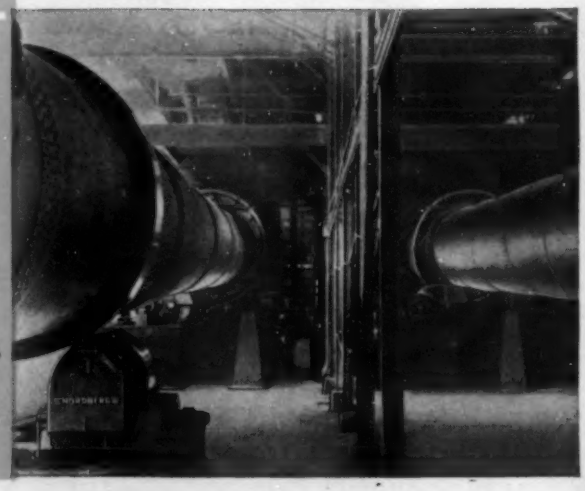

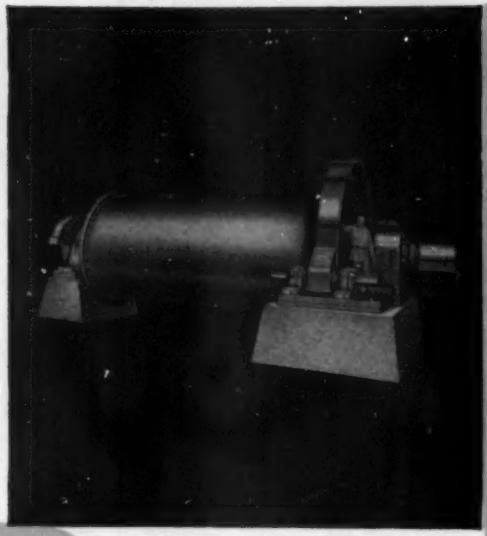

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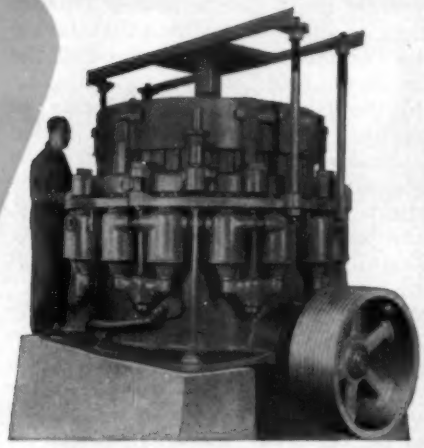

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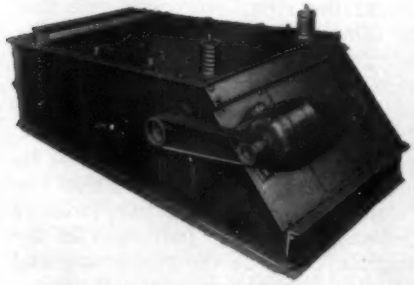

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SYMONS . . .

A REGISTERED NORDBERG TRADEMARK KNOWN THROUGHOUT THE WORLD

GILBERT LaBINE of Canada and Joseph H. Hirshhorn of Brooklyn shape up as the Mr. Bigs of Canada's uranium industry. They don't like each other. Together, but separately, they will be responsible for a tremendous increase in Canada's uranium production. Mr. LaBine controls Gunnar Gold Mines, certain to be one of Canada's most important uranium producers. Mr. Hirshhorn owns the Rix-Athabasca, Pronto, and Algom uranium mines.

According to one source most Canadians who have bothered to take sides favor Gilbert LaBine, the native son. The battle is a strange one. Neither opponent for the title of uranium king seems aware of his adversary. But while Mr. LaBine goes on ignoring Mr. Hirshhorn, he is certain that Gunnar will be the most significant of the north country's uranium producers. Mr. LaBine has been around a long time. His first big discovery was the Eldorado, taken over by the Government during World War II.

Mr. Hirshhorn, however, is said to be slightly irreverent when Mr. LaBine is brought up during a conversation. He is reported to imply that his Canadian counterpart is living on past glory. The Brooklynite expects his Pronto mine to beat Gunnar into production. The hot rumor on the uranium circuit is that Mr. Hirshhorn is negotiating a $50 million deal to finance his orebodies. If it comes off, it will probably be the biggest uranium deal to date and one of Canada's largest mine financing operations of all time.

Possibly the most important man in the entire Hirshhorn organization is Franc R. Joubin. Hired as a consultant by Mr. Hirshhorn in 1948, Mr. Joubin is a chemical engineer who became a geologist and prospector. When the Canadian Government opened the Beaverlodge area to uranium prospecting, he went north. Between 1948 and 1950 he developed Rix-Athabasca. Returning to Algoma, Mr. Joubin started working full time with Mr. Hirshhorn, who was buying up likely properties.

Geiger counters showed that uranium was around —but samples proved something less than exciting. But Franc Joubin came through with the discovery that nature had leached away the outcroppings. There was plenty of uranium deep beneath the surface. Last year the $6 million financing for the mill was arranged. It is expected that within months Pronto will be in production at a rate of about 1000 tpd—and 1500 tons by 1957. But Franc Joubin is most excited about the nearby Algoma properties. The two men envision the orebodies in terms of millions of tons and two 3000-ton mills.

Joseph Hirshhorn financed Rix-Athabasca on a shoestring—about $5000 according to Franc Joubin. It was only last year that he managed to get the money needed to put the mine into production. Mr. Joubin is jealous of only one man and one thing in Canada—Gilbert LaBine and his Gunnar. That he wishes he could have.

So, thousands of people this year will take to the woods and wilds, looking for the telltale clicks that may sound the clarions to a fortune. Some of them may find the stuff that dreams are made of—a lot of them won't. But at least one man is doing some heavy thinking about the future of uranium. He's Canada's William J. Bennett, president of the government's Atomic Energy of Canada Ltd. By 1967 uranium production may hit about $100 million. He speaks of a nuclear power plant and the gigantic energy requirements that uranium can fill. But he also speaks with caution. Within a decade, uranium production could hit such peaks as to outrun the demand, dragging the price down. Uranium producers have been told the Canadian Government will enter into no purchase contracts beyond 1962.

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THE Joint Committee on Atomic Energy of the Congress recently heard Commissioner Thomas E. Murray say that, "I am of the opinion that during the past year the Commission has lost some of the stature it previously enjoyed."

He pointed to the Dixon-Yates controversy as the chief unhappiness within the AEC. He denied the validity of the argument that the contract is "merely an extension—and indeed an improvement—on a pattern which I established, namely, that of using combinations of private utilities to meet the exceptionally large power requirements at AEC installations."

Commissioner Murray stated that the Dixon-Yates combination is an attempt to meet the civilian commercial needs in the Memphis, Tenn., area, hundreds of miles from the nearest AEC installation. He testified that he signed the contract last October because he believed "quick deposition of this matter by the Commission was in the public interest." He hoped that the signing of the pact would free the Commissioners and their staff from protracted deliberations and permit them to devote their energies to other primary responsibilities. He regrets that that hope has not been fullfilled.

Mr. Murray placed considerable emphasis on the need for maintaining the complete confidence and trust between the Commission and the Joint Committee. In another part of his statement he noted that industrial atomic energy would become a reality in proportion to the importance attached to the program.

It seems fairly obvious that the AEC has lost its sacred cow status. Until now, the Commission has been sacrosanct. Congress is almost certain to make it a target for investigation. One soft spot in the atomic energy program could be the processing end of the Colorado Plateau operation. Jack R. Ryan, *New York Times* reporter, did some rooting around and came up with a few things. In an article in the Sunday business section of his paper he says:

"Is a bottleneck developing in uranium production? Officials of the Atomic Energy Commission say no. But many uranium and milling people say yes, and contend that AEC policies are holding back much-needed expansion of uranium milling capacity."

Mr. Ryan says that an ore build-up has been going on for some time. General K. D. Nichols, general manager of the AEC who recently resigned, told a Senate appropriations subcommittee last

April that ore was not being processed rapidly enough. Last October Carol Wilson, former general manager of the AEC, told the National Industrial Conference Board that the uranium miller doesn't have the possibility of high profits the miner has.

To refer again to *The Times* article, the trouble seems to be that the Government is interested in getting the lowest possible price for concentrate rather than promoting the expansion of mill facilities. The AEC negotiates separately with each mill.

Added to the other woes of the AEC are indications that not all is light and joy on the Commission itself. Lewis L. Strauss, AEC chairman, and Mr. Murray clashed recently over Dixon-Yates for the third time. It is not likely that the break will heal rapidly.

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UNDERGROUND factory-type illumination is still in the speculative stage. But there are people who are giving it considerable study. During 1954 its use underground was investigated by the Mining Development Program of Bituminous Coal Research Inc. Demonstration units were installed in two West Virginia mines. Both area lighting and face lighting are being developed from a practical and economic viewpoint. Following World War II, the first fluorescent lighting system was installed in a British underground operation. Lately, the Eregli mines of Turkey have adopted fluorescent lighting. When the Turkish system is completely installed it will comprise thousands of fittings that will bring daylight working conditions to all mine roadways.

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THE National Labor Relations Board threw a fast strike past Mine, Mill, & Smelter Workers and its local unions when it announced that the union and its locals would no longer be permitted to bring cases before the board. The NLRB declared the union out of compliance with the non-Communist oath required by the Taft-Hartley Act because a union officer admitted in an article in the union's newspaper that his affidavit was false.

As a result of the ruling, the Mine-Mill will no longer be able to bring cases to the board, participate in representation elections, or make valid union shop agreements.

Maurice E. Travis was the officer who made the newspaper statement. According to the NLRB the union secretary-treasurer, in addition to proving his affidavit false, showed undisputed evidence at the board's hearing that he had not since changed his allegiance to and support of the Communist Party nor his belief in the forceful overthrow of the U. S. Government.

The union has announced that it will fight the ruling all the way to the Supreme Court. In a formal statement the union said:

"Obviously this is the attempt of a government agency to answer Harvey Matusow's sensational exposure of his testimony in the Jencks case. An affidavit by the ex-professional witness Mr. Matusow, was filed . . . in El Paso federal district court. It said specifically that Mr. Matusow's testimony throughout the Jencks case was a fabric of lies. And as Charles F. Herring, the chief prosecuting attorney in the Jencks case, said himself, Mr. Matusow's testimony was 'absolutely essential' to conviction of Jencks."

The exact connection between the two is vague at best. However, Mine-Mill goes on to say that the NLRB proceeding against Travis is illegal, a stand it has maintained for more than a year. It is the union's contention that the NLRB has no jurisdiction to test the validity of T-H affidavits. The tie the union does make between Matusow and the current case is the fact that the entire proceedings of the 1952 Salt Lake hearings were brought into the current hearing. Matusow was a witness at the former hearing. The statement makes no mention of the article that appeared in the union's paper.

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NO one can fix an exact date for the Industrial Revolution. The revolution was the sum of many things—not the result of the creation of one new industrial machine. In the same way no point in time can be assigned for the age of automation. Some believe that it has already started. Probably so. That exact dates cannot be fixed for either the Industrial Revolution or the automation era is unimportant.

Whether automation will result in increased productivity and creation of new jobs in building and maintaining new machines, or add more employables with no place to go to in the labor market, Industrial Psychology Inc. feels is a moot question.

The prediction is that 20 million new jobs will be needed between 1955 and 1975 to occupy the 85 million persons expected to compose the working force within the near future. It ties in with the predicted 221 million population by 1975. Thus the old Malthus theory of whether the supply of goods can keep up with the population growth is being rewritten to read: Can the supply of jobs keep up with job applicants. Industrial Psychology Inc., national pyschological research organization, sees automation definitely complicating things, with "the machine replacing the workers' brain in office and factory."

Some conclusions can be drawn right now. Starting in 1955, and intensified by 1960, management will have a greater selection of applicants. Another implication, again according to Industrial Psychology Inc., is that employers will have to take a more critical look at present work force, weeding out inefficient performers lacking basic pyschological traits to do a better job. The research center's attitude is that employers might be doing those employees a favor—job hunting in the 1960's may be tough.

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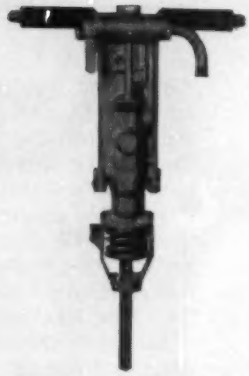
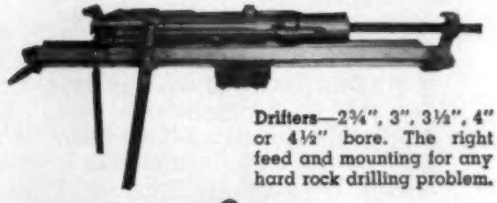


Sinkers—hand-held or feed-leg mounted. The right combination for every rock.



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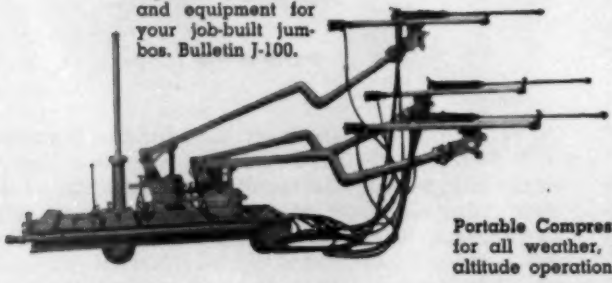

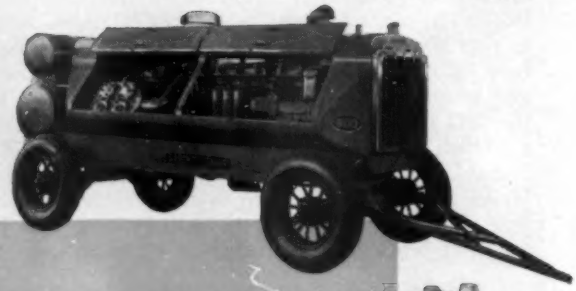

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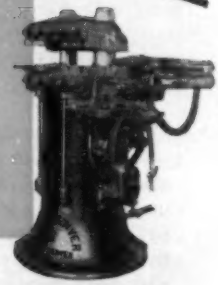

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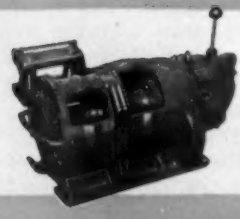

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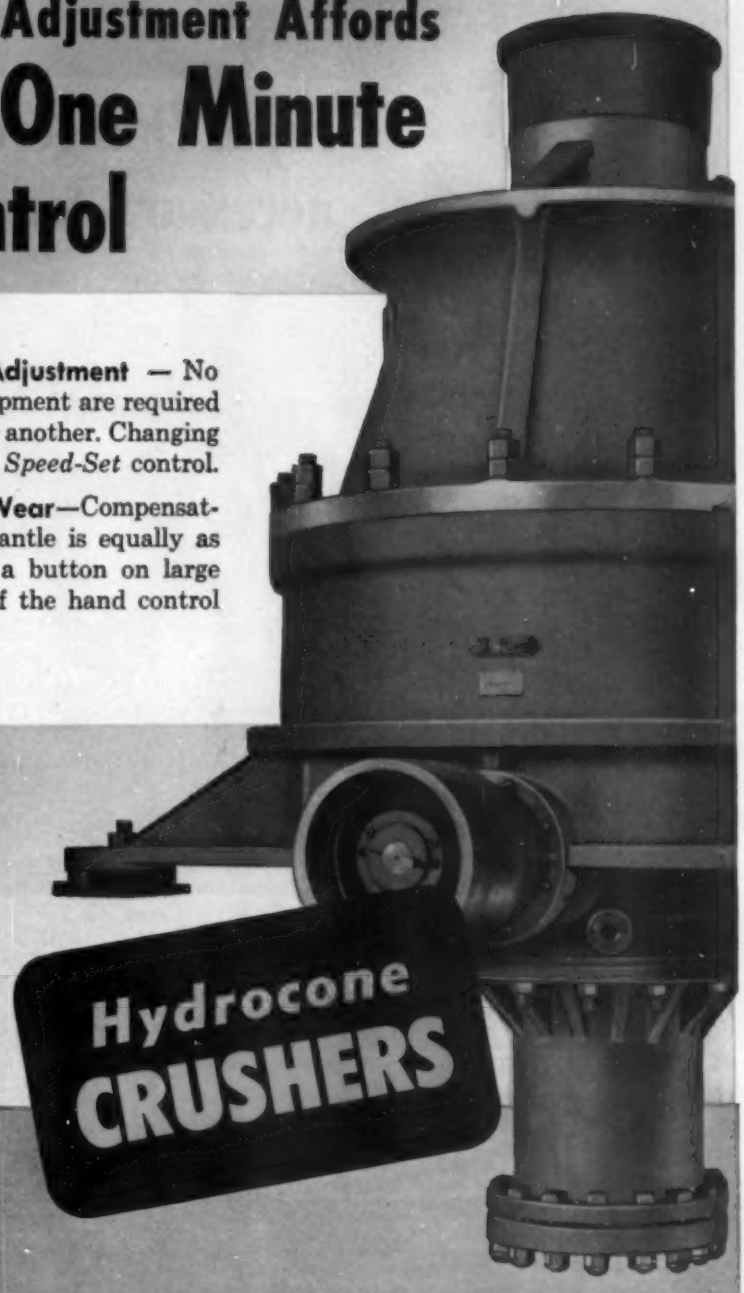

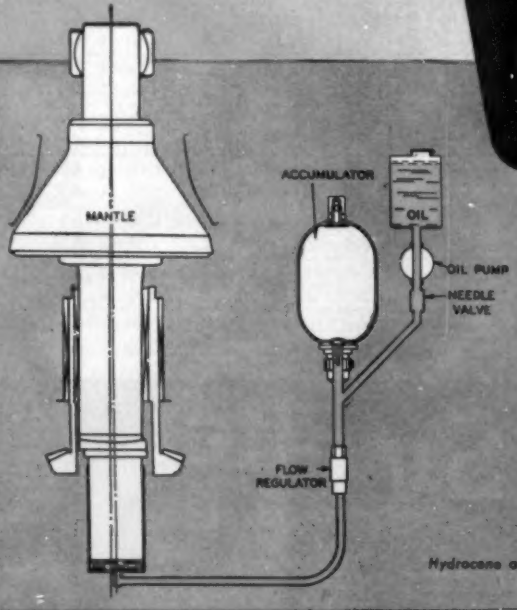

How *Speed-Set* Control Works

Mainshaft assembly is supported on hydraulic jack. Oil pumped into or out of jack raises or lowers crushing mantle.

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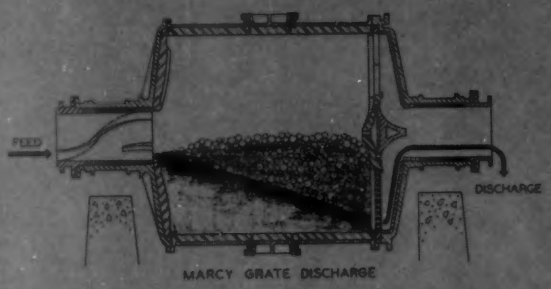

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The "rapid change of mill content" is accomplished by use of the Marcy full grate discharge on ball mills and the open end feature on Marcy rod mills. This results in a low pulp line which provides an active, *effective* grinding mass to act on particle size reduction *only*...there is no wasteful cushioning action by high pulp levels. There is a faster migration of fines than oversize particles, thus less overgrinding.

operating proof of Marcy Mill superiority

(typical tests conducted independently by operating companies)

LOCATION	Mill Size I.D. Shell Dia. x Length	DISCHARGE	RPM	% C.S.	HP Input	Tons Per 24 Hrs.	KWH Per Ton	% Gain Capacity	% Power Increase	GRIND	% Capacity Overflow Mill Compared to Grate Mill
Arizona	10½ x 11	Overflow	16.6	77.6	665	1610	7.40			12% + 48 M.	87
	10½ x 11	Grate	16.6	77.6	700	1850	7.02	15	5.2		
Colorado	6½ x 6	Overflow	25	79.1	102	160	11.5			11% + 65	70
	6½ x 5½	Grate	25	79.1	112	226	8.9	41.3	9.8	10% + 65	
Idaho	6½ x 4½	Overflow	25	79.1	75	98	13.7			1% + 65	77
	6½ x 4½	Grate	25	79.1	91	127	12.8	29.6	21.3	1% + 65	
Mexico	8 x 6	Overflow	22	80	180	660	5.1			Open Circuit	75
	8 x 6	Grate	22	80	230	880	4.6	33.3	22.3		
Arizona	8 x 6	Overflow	22	80	197	646	10.89			6% + 48	70
	8 x 6	Grate	22	80	242	928	9.34	43.7	22.8	5% + 48	
Canada	6½ x 14½	Overflow	24.5	81	323	1117	5.17			8% + 65	78
	6½ x 14½	Grate	24.5	81	390	1430	4.88	28.0	20.7	7% + 65	
Colorado	9½ x 7	Overflow	19	74.5	287	900	5.7			35% + 100	81.7
	9½ x 7	Grate	19	74.5	338	1100	5.5	22.2	17.8	35% + 100	
Canada	6½ x 12½	Overflow	18.5	59	274	945	5.2			15% + 65	73.4
	6½ x 12½	Grate	18.5	59	331	1289	4.6	36.4	20.8	15% + 65	

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REPRESENTATIVES IN FOREIGN COUNTRIES

EVERY year, the Annual Review Issue reminds us of the valuable contributions made by volunteer workers among the membership to MINING ENGINEERING and the AIME. Seven authors devoted much of their spare time in 1954 to give you, the reader, the most complete roundup of technical activities in their respective fields available anywhere. These men have performed this service without payment other than a job well done.

This is always a gratifying experience to the editors in a day and time when little is done without direct monetary returns. But it is this type of activity that keeps MINING ENGINEERING and the Institute on the road to progress. There would be little chance that this organization could continue to function if the employed staff had to do the thousands of tasks carried out by interested members.

We should all know these men better, not by intimate details nor biographical data, but by the reasons why they do work far beyond the call of duty. For instance, **Bob Loofbourow** is a consulting mining engineer with years of experience in mining and shaft sinking. When we asked him to do the Mining section of this Review, we received a favorable reply from him through his wife, as he was then in an isolated area of Canada. In spite of an extended stay away from home and correspondence facilities, he still produced the goods.

Going down the list of important men behind this issue, **Stan Michaelson** when he was with TCI in Birmingham took on the job of writing the Minerals Beneficiation article. Later in the year, Stan moved on to Kennecott at Salt Lake City, but even moving his family and belongings across the country did not discourage him from working on the article. Then Kennecott decided to send him to Finland just about the time he was finishing the manuscript. But this was no problem for the Chairman of MBD to overcome, because another well-known contributor to AIME, **Norman Weiss**, took over for him and the results are on page 258. It was suggested that we put Norman's name in larger type, since Stan has reluctantly told close friends that Norman really did most of the work, but we think it was a co-authorship deal.

Bob Stephenson, a long-time stalwart of the Industrial Minerals Div., was placed in a most trying situation for writing a Review story. His "income-producing" employment keeps him out of the office for prolonged periods of time, making creative writing in his spare time not the most desirable recreation.

Through extensive secret correspondence among the members of the Geophysics group, **Hal Mooney** graciously went to work preparing his review. We have been informed that he sent out over 400 inquiries all over the world to gather the material. Some even went behind the Iron Curtain. His was definitely not a problem of having enough information for the article, but rather one of digesting it intelligently.

Ed Clark did a great job spliced in with his important civic work and a long stay in Washington while on a special Cabinet Committee for Water Resources Policy. Ed is most active in the Missouri Highway Planning Committee, and an auto drive through that state will show that the work of this group has been productive.

As always, **Maurice Cooper** came through with flying colors. Through his affiliation with the National Coal Assn., he has been able to pass on the first-hand dope on the coal industry to you. For many years, Maurice has been working closely with students, particularly of high school level, and has given a measurable boost to the prestige of the profession among those who are still potential candidates for mining training.

Last, but by no means least, we mention **S. H. Ash** with a moment of silence, because he, unlike the other six authors, is a veteran of Annual Review issues. We would not want to recite the number of years that he has either written the Safety Review or guided its preparation. Each year, he enthusiastically agrees to submit the information and each year we continue to enthusiastically ask him. An imposition well taken is hard to beat.

This small group of authors is certainly in line to receive the *Order of The Silver Spad* or the *Citation of the Gold-Plated Ball Mill* for meritorious service to the pages of MINING ENGINEERING and the members of AIME. In addition to these men, there were hundreds of correspondents whose names receive little recognition for the data they forwarded to the writers. This is the editors' tribute to all of them. We feel that our thanks for their efforts are most inadequate, but the best we can do, except send free copies of the magazine in lieu of just payment.

THE most northerly report of the year concerning AIME activities is the one about the MBD session at Helsinki, Finland, a few miles north of the 60th parallel. Stan D. Michaelson, globe-trotting MBD Chairman, attended the meeting in the country where the national pastimes are building good plants and taking sauna. John Ryselin, chairman of Vuorimiesyhdistys, which is the Finnish Mining Society, and also general manager of the Outokumpu Smelter, largest Finnish copper producer; Petri Bryk, managing director; and Toivo Toivanen, smelter superintendent, both of Outokumpu, were also in attendance at the *rump* session. Mr. Michaelson says that the new mill at Outokumpu is unquestionably one of the best modern plants that he has seen. According to the MBD head, the Finnish mining industry has been taking giant-size steps in metallurgical progress.

C. M. Cooley

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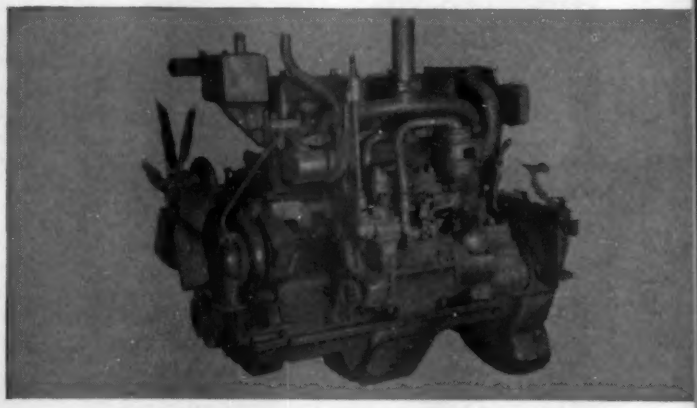

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THE NEW D7... MORE POWER, SMOOTHER PERFORMANCE

Metal Mining

Edited & Compiled by R. L. Loofbourow

Trends in the metal mining industry were definitely down in 1954. With a record in 1953 of $1.8 billion output, the last year dropped to $1.5 billion, the lowest value since 1950. The decrease in iron ore production alone accounted for at least 10 pct of the decline.

PROBABLY more than any previous year, political debates of 1954 marked a new high for the mining industry. Lead and zinc prices gave forth with minor rallies producing no real improvements. An anticipated drop in copper prices never came to be. Early in the year arguments for more free trade versus tariffs to restrict imports were voiced eloquently by Charles P. Taft, president, Committee for a National Trade Policy, and Andrew Fletcher, president, St. Joseph Lead Co.

Before the Colorado Mining Assn. meeting, Mr. Taft stated: "The fear of what is going to happen from imports . . . is not always justified. I cannot accept the inference that if imports are allowed to come in, the zinc and lead industries of the U. S. are going to fold up." Andrew Fletcher's reply to this statement was: "Look at the domestic lead and zinc industries. Was our fear justified or not? We are talking here about what did happen as a result of imports, not only what may happen."

With all the discussion, however, the problem is far from being resolved. The Government started stockpiling lead and zinc to give the domestic producers a boost, but the full effects of this program have not become apparent.

Following ten months of examinations and testimony from 360 witnesses, Sen. George W. Malone's Minerals, Materials and Fuels Economic Subcommittee published a 380-page report. The principal conclusions developed were: "The Western Hemisphere can be defended and will be the only dependable source to the U. S. of critical raw materials in the event of an all-out war" and that, "during the last more than a quarter of a century, established procurement practices have dangerously increased

Looking southeast at the new Storke Level installations of the Climax Molybdenum Co. This is the surface plant for handling the large tonnage opened up by the level. The main building on the right is the crusher where the 60-in. Nordberg gyratory is located. Adjacent to the crusher structure is a 3000-ton earth-fill ore bin which appears as an inverted cone. In the background are two 14,000 ft peaks, Mt. Democrat on the left and Arkansas Mountain on the right. The valley between these peaks is the beginning of the Arkansas River.

our dependence for critical materials upon the nations across major oceans."

On the basis of these conclusions, the Subcommittee made several major recommendations: 1) Abandonment of the Reciprocal Trade Program; 2) A U. S. mineral policy based on self-sufficiency of the Western Hemisphere; 3) Increased depletion allowances to miners as a further incentive to production; 4) Accelerated Government stockpiling; 5) Investigation into SEC control on mining securities; 6) repudiation of all "international controls on production, prices, and supplies of critical materials; 7) $50 million annual Government appropriation for a five-year research program on improved beneficiation methods and substitutes; and 8) Expansion of titanium production with 150,000 tons per year as the goal.

The measures outlined are most extensive, but the degree to which they are adapted by the present Administration is something yet to be seen.

Industry has Split Personality

Using the situation in the petroleum industry as an example, it is noted that the mining group is similarly inconsistent. On the one hand, it asks for Government interference, but on the other it wants minimum contact with Federal authorities. Gardiner Symonds, addressing the American Petroleum Institute in November, said that is difficult for the industry to present a strong case for less Federal regulation of prices while at the same time it is urging more restrictions on imports. He was talking in connection with the Phillips Case in which the Supreme Court, interpreting the Natural Gas Act of 1938, thrusts on a reluctant Federal Power Commission the regulation of prices paid independent producers of natural gas by pipeline or gathering companies which send gas to other states. The position of the independent producer is similar to that of a coal mine selling all or part of its product to a power plant that makes and sells electrical energy in other states. It is little different from the position of any producer of iron, copper, lead, lime, cement, timber, automobiles, wheat, or corn.

It is not clear that the industry will shake its split personality, but these events may have caused many to consider the desirability of adopting a strong, consistent program.

Production Highlights

Increases in nonferrous production are typified by the opening and expansion of Gaspé Copper, the Lavender pit, Yerrington, Copper Cities, Silver Bell, San Manuel, White Pine, and Nicaro. It is easy to see that most of the expansion was in the low grade copper operations. But any one of these new or enlarged plants is to an extent living proof of a phrase that has almost become the motto of the mining industry. "If you can't mine by open-cut or block-caving methods, then forget it." Conditions as they are, it seems that a small, tight underground operation is not too feasible, thus the small mine man is rapidly disappearing.

Going back to the large low grade deposit, and the strong drive for new open-pit copper plants,

Below are two views of the Pilotac taconite plant of the Oliver Iron Mining Div., U. S. Steel Corp., at Mountain Iron, Minn. The open pit mine will feed ore to the experimental concentrating plant scheduled to produce 500,000 tons of plus 60 pct iron concentrates annually. Run-of-the-mine ore has an iron content of 25 to 30 pct.

White Pine copper mine in the Upper Peninsula of Michigan is now in its final stages of development. The dome-shaped bedded deposit is developed for mining with large trackless equipment. Ore will be crushed underground and carried to surface on conveyor belts. Milling will involve grinding, flotation, and regrind for further cleaning of concentrates. Mill product will be mixed with flux and conveyed to the smelter feed building and then to the reverberatory furnace. Conventional methods in the smelter will produce fire-refined lake copper.

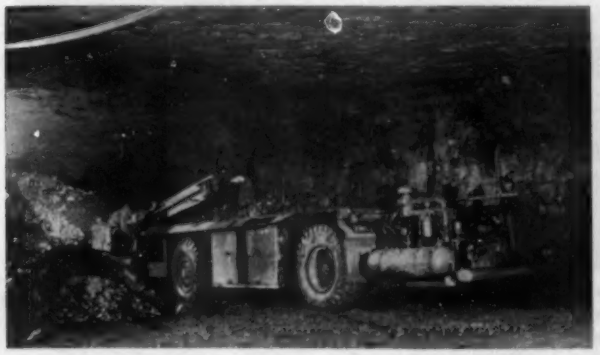
Harrison Schmitt made the following observations concerning these operations:

> Many mining people, even some of those in the Southwest, may not appreciate or realize the implications of the new technologies and more nebulous future possibilities when applied to the porphyry copper deposits. The point is, of course, that lower costs mean that a lower grade of ore can be mined at a profit. There is often marginal ore bordering on the higher grade, and present orebodies usually have assay limits. The most rapid decline in costs has been in open pit excavation where under the most favorable conditions there is reason to believe that costs can be as low as 15¢ per ton. Certainly 25¢ per ton is now realized in a few mines and may soon be reached in others. Depending on conditions, costs apparently as low as 50¢ per ton can be realized in milling. Development costs are being lowered by new and improved methods. Amortization is, of course, a function of the size of the ore body, but the amount of feasible capital investment may vary with conditions—33¢ per ton may be an average cost of amortization. Overhead varies with capacity, but 22¢ per ton may be average. (*See p. 234*)
>
> On the basis of 85 pct milling recovery, an average return of around $2.29 per dry ton will be needed to defray all costs before smelting, refining, and marketing. These items amount to around 6¢ per lb of copper. On a 25¢ market, then, we get about 19¢ from the smelter for the copper. This means that only 12 lb of copper, or 0.60 pct Cu, is needed to break even on the *average* deposit. This indicates also that the cut-off point is reaching down to as low as 0.40 pct Cu provided there is enough ore above 0.60 pct to carry the amortization and overhead for the lower grade ore. It is to be noted that the grade of some of the protores exceeds 0.35 pct Cu.
>
> The prospects of further reductions in stripping, mining, and milling costs are good, particularly if lower cost sources of power are developed. The *Wall Street Journal* of Oct. 19, 1954 mentions a new cleated conveyor belt that can be used at angles up to 45°. This should make it possible to lower costs in some pit and underground operations. The possibility that we will mine some of the better protores and lower grade enriched ores, say, down to 0.40 pct Cu within a decade or so does not appear to be too speculative. Particularly, if much of the stripping has already been done for the higher grade ore and the equipment, plant, and housing is available from previous operations and the demand for copper does not decrease materially.
>
> Perhaps the implication of analyses such as the one given above is in part responsible for the unusually strong drive for new open pit coppers. Price is not the main factor since, rightly or wrongly, a *future lower price for copper appears to have been discounted.*

Iron Ore Production Drops

Iron ore production was substantially lower this year than in 1953 due to cut backs in steel output, but five major projects moved forward.

In the new White Pine operation, underground handling will be mechanized. On the left is an 18-ton Dart diesel-powered shuttle car being loaded by a crawler-mounted mucking machine. On the right is a small section of the 252 flotation cells used to treat the White Pine chalcocite ore.



Estimated Average Open-cut Costs per Dry-Ton	
Development and purchase	$0.10
Stripping	0.40
Mining	0.25
Hauling	0.05
Milling	0.60
Overhead	0.22
Amortization	0.33
	$1.95

The first shipments of ore were made from Labrador as well as from Cerro Bolivar. Both Labrador and Cerro Bolivar required large capital expenditures before a ton of ore was shipped and are by far the largest in the history of mining. These projects were completed without subsidy and are a tremendous tribute to private enterprise.

Also noteworthy in 1954 was the completion of the $45 million expansion program at the Climax mine of the Climax Molybdenum Co., now the largest mine operating in North America with an average daily production of 28,000 tons. The mine, located atop 11,300-ft Fremont Pass, produced over 8 million tons of ore from two levels in 1954.

The Colorado Plateau continued to be the second Klondike gold rush and speculation for quick wealth continues.

It is also significant that large companies were seen moving into the field as compared with a few years ago when most of the uranium prospecting and mining was done by individuals and small companies.

Permian Basin Potash Expanding

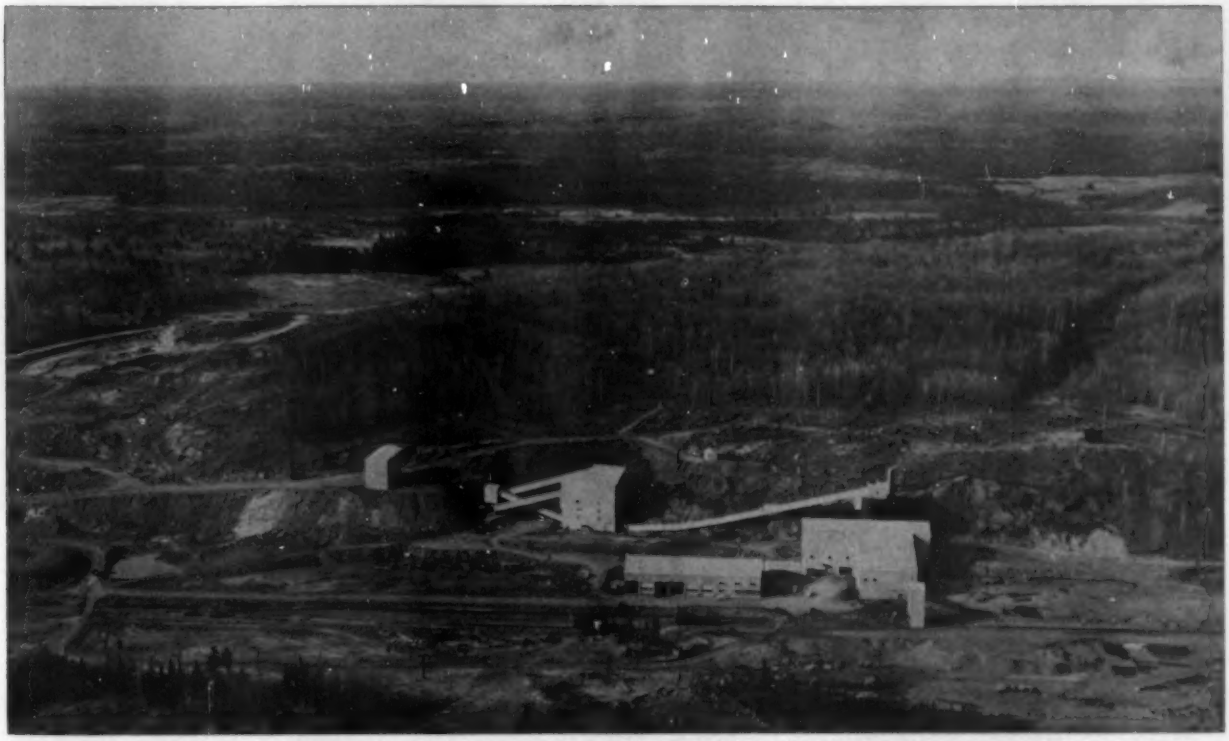
The Carlsbad potash field has seen the addition of two new large companies. Freeport Sulphur Co. is reported joining forces with the Pittsburgh Consolidated Coal Co. for a $16 million development. This new mine northeast of Carlsbad will have the second Koepe hoist installation made in the U. S. Also, the National Farmers Union and the Kerr-McGee Oil Industries are forming a new corporation to develop holdings in that area.

Technical Developments Benefit Industries

Two developments in core drilling promise to help the geologist and mining engineer pre-design and estimate the cost of underground work and better evaluate ore deposits. The NX borehole camera (MINING ENGINEERING August 1954) will aid the engineer in seeing defects in the walls of holes as well as have actual photographs of the work encountered. The use of a newly developed wire-line core barrel in diamond drilling stands to increase core recovery and reduce drilling costs.

Borehole Camera—One of the most unique and practical developments in the field of sub-surface exploration in recent years is the NX borehole camera. The instrument was developed to increase the utility of core drilling, the principal device employed by engineering geologists in evaluating foundation conditions at construction sites. Frequently confronted with cores representing only a percentage of the bedrock materials penetrated by the borings, the geologist is faced with the problems of determining the cost of core losses. The need for a camera which could provide an answer to this all important question was recognized by the geological staff of the Army Engineers in 1944, and eight years later a pilot model camera capable of producing continuous color pictures of the surface of a

In spite of the decline in activity in the steel industry, new sources of iron ore were opened in 1954. Here is the completed dock and loading installation of the Iron Ore Co. of Canada at Seven Islands on the St. Lawrence River. The end-point of the 360-mile railroad from the open pit mines at Knob Lake has complete crushing, stockpiling, loading facilities for 70,000 tpd.



Aerial view of the Humboldt open-pit and flotation plant near Ishpeming, Mich. This is the first concentrator for iron ores using flotation. The feed to the mill is a hard, finely disseminated hematite in jasper, not amenable to magnetic concentration as are the low grade ores now being developed on the Mesabi Range of Minnesota.

3-in. diam hole was perfected. This device has since been proved and modified to such a point that it is capable of photographing the interior of holes up to depths of 2000 ft.

A modification which was developed by the Bureau of Mines is being adapted to mining research studies of subsidence and mining by caving.

Wire-line Core Barrel—In a report by V. N Burnhart of the E. J. Longyear Co., it is stated that diamond core drill operators are witnessing an entirely new approach to the problems of core recovery and drilling progress. The development of this special core barrel and the operating techniques was started in Virginia in 1946.

To give some idea of the improvements Mr. Burnhart describes the wire-line drilling cycle as:

After a full run, the drill string is lifted a foot or more, the over-shot assembly lowered, the innertube hoisted to the surface and a new innertube is either dropped or lowered on the wire-line.

The advantages of the wire-line method are: 1) The entire drill string remains in the hole until the bit needs replacing; thereby increasing the net drilling time; 2) A sturdier core barrel results in longer life; 3) This method demands less manual effort than conventional techniques, and is adaptable to either screw or hydraulic feed; 4) With improved drill hole stabilization, there is much less caving, premature blocking, and increased bit life; 5) Short core runs in difficult ground are not prohibitively expensive; and 6) Saving of time and expense in drill hole surveying accomplished through the inside of the drill string.

Angle and vertical holes have been successfully drilled to depths of 4600 ft. Drilling of 43,000 ft has resulted in 98.7 pct core recovery with lower costs due to increased drilling time.

The greatest benefit accruing from this method appears to lie in the high percentage of core recovered. Of great advantage too is the increase in net drilling time, particularly as the depth of drill holes increases.

Mining Equipment for Operators Needs

Throughout the history of mining in the U. S. the development of equipment and of mining techniques have been more or less divorced from each other. In recent years and particularly in 1954 a definite trend towards the development of equipment especially adapted for a particular operation has progressed.

One significant example of this is the new long hole equipment placed on the market by the Gardner-Denver Co. Also, longholing has been a headache as well as a lifesaver to many mining operations. It has been accomplished with standard drilling equipment involving only minor modifications, but now this new machine has a 4½-in. bore. It is also adapted to make use of an enlarged shank section equipped with an internal "O" ring to give better flushing of the hole. The drill is designed particularly for drilling long blastholes.

Also, the miners using the trackless equipment method have long felt that a front-end crawler mounted loader built to stand up under the rough treatment received in their mines was yet to be built. The Eimco Corp. made the first step in this direction with the heavy duty Eimco 105 loader. These are all worth-while results of the common understanding between mining equipment manufacturers and mine operators.

Additional information on mining activities in Mexico and Africa is in the "Geology and Exploration" article of this issue. Specific data appears on pages 248 through 250.

Open-cut mining in the uranium industry is just getting under way. Anaconda's Jackpile mine, near Grants, N. M., is the only large pit now in operation. Over 1 million cu yd of overburden has been stripped from the orebody before mining. Earth-moving equipment of the size shown is not in general use for uranium mining, but this trend will continue to improve production costs.

Uranium Mining Still At High Pace

by R. H. Toole

Southwestern Colorado and southeastern Utah produced most of the radium and vanadium ore and are still the major source of uranium ore production. The area in which new mines are found has expanded south into Arizona and New Mexico, northward into Wyoming and South Dakota, eastward to the front range of Colorado, and westward into Nevada and California. An intensified search, encouraged by a price structure guaranteed through Mar. 31, 1962, is in progress. Coupled with this is a bonus program that provides for additional payment equal to the base price and applies to the first 10,000 lb of U_3O_8 produced from new sources until Feb. 28, 1957. Bonus payments have reached a total of about $4.5 million. Ore production has been doubling every 18 months and future expansion at this rate or better is expected.

A good measure of the industry's growth is the interest and participation, especially during the last two years, of most of the mining companies operating in the western United States. A listing of those engaged in the search for uranium looks like a "Who's Who of the Mining Industry." Two years ago this statement would have been untrue. Stepped-up activity has caught the imagination of the public and frequent comparisons have been made to the gold rush days of the early West.

Primary vein-type deposits contribute some production and may provide more in the future, but at present the greatest source of uranium ore is from bedded sedimentary deposits. Orebodies occur in all sizes from a few tons to over 100,000 tons, but only about fifteen known deposits exceed the latter figure. Two of those ore bodies are classed as containing in excess of 1 million tons. Thickness of ore varies from 1 to 25 ft, with good to poor continuity. The deepest shaft now in operation is 600 ft vertically. Future finds may be at greater depth because exploration drilling is now to 1000 ft.

Access to the shallower ore deposits, where open pit mining or adits are not practical, is usually an incline driven on a dip of 12° to 25°, depending upon the equipment used. These inclines do not require large hoisting installations and can be put down economically.

When depth of ore exceeds 150 ft, the advantages of an incline are usually outweighed by those of the vertical shaft. The disclosure of ore at depths of over 200 ft has resulted in the sinking of a number of vertical shafts, most of which are two-compart-

Underground mining on the Colorado Plateau area does not stimulate the use of large crawler-mounted jumbos, because of the small size of the deposits. However, at this Big Indian Wash, Utah, operation of the G & G Mining Co., it has been a valuable asset in breaking ore in high stopes. This mine is a portion of the Charles Steen property.

ment. Calyx holes of 36-in. diam are being used for hoisting shafts in one locality, but the application is limited by depth and by the character of the rock through the shaft must be driven.

Most of the mines are dry and the pumping is seldom necessary. In the few cases where water is encountered, the amount is generally small; therefore, costly pumping equipment is not required. The water thus gained can be used for drilling, saving water haulage costs.

In general, the problems of the miner are associated with increasing depth of operation and increased distance from the working face to mine entry. Most operations do not have power unless generated at the mine. This limits selection of equipment.

The rock is rather easy to drill and break. Separate blasting of ore and waste is often required. In many cases, deep rounds are not advisable if ore is to be mined clean. When selective blasting is required, the cost of mining rises in proportion. The careful workman, by watching drill cuttings, seldom needs to blast waste with ore. Although color of ore is usually a practical guide in mining, it is not an infallible indicator of ore grade. Samples of material in the mineralized zone must be taken at frequent intervals and the uranium content determined by assay or Geiger counter.

Where close spaced prospect drilling from surface is not economical, by reason of depth, longhole drilling from the mine workings is practiced to find ore. A wider application of this method is indicated for the deeper deposits.

The lenticular orebodies are small in most deposits and allow enough barren pillar support, though a few well placed timber props are often needed. The larger deposits and those close to surface, say within 10 to 15 ft, are exceptions. Rock bolts have been used for roof support in a few operations and have proved their worth.

Due to dip of ore-bearing strata, underground haulage is a major item of mining cost. Plans can be made for orebodies that have been outlined by drilling prior to the start of mining, but many of the older mines "just grew" and are stuck with an awkward haulage system. Track and trackless haulage are being used with success. The machinery available for track haulage is of standard manufacture that has been proven in other mining areas and adapts well in uranium mining wherever the deposits are not steep dipping. Compressed air powered locomotives have found favor with many operators using this type of haulage.

Trackless haulage has been hampered somewhat by the lack of standard equipment, but many adaptations have been made. One piece of equip-

ment widely used is the small three-wheel shuttle car, which holds about one half ton of muck and is powered by a small diesel motor. This small car has a limited range of operation due to slow speed of travel. Tractor loaders are also used and perform both mucking and haulage functions. Among the wide variety of trackless methods in use, the horse-drawn rubber-tired cart is still with us and a considerable volume of ore comes out in wheelbarrows. A trackless carrier of more universal application will probably be developed because the industry has need of it.

Open pit mining is applied to deposits at or near surface, but such operations are few. One large open pit mine is now in production near Grants, N. M., where approximately 1 million cu yd of overburden will be stripped and another nearby orebody has been discovered that will require a similar stripping operation.

The foregoing is a brief picture of the present status of the industry. Plans are being made for many advancements in mining practice, especially where the larger ore finds warrant the expenditures involved. The industry is experiencing growing pains and boom psychology, but the future looks bright indeed.

Mining In Utah

by Miles P. Romney

The year presents a varied picture for mining in Utah. Nonmetallic and iron mining and processing continued their strong expansion trend. Copper production, due to voluntary curtailment during the forepart of the year and strikes in August, was materially reduced, although the scale of plant expansion exhibits strong confidence. Lead and zinc mining operations continued under adverse conditions with mine production at about the same level as 1953. Stockpiling gave an artificial stimulus to lead and zinc prices which succeeded in pushing lead to a nominal price range but left zinc at a subeconomic level at year end. One mine and one lead-zinc mill reopened near the year end on the strength of the improvement.

In the nonmetallic field a strong trend beginning about the end of World War II was sustained during the year in both plant expansions and new plants to utilize Utah's great variety of such deposits.

The Westvaco Mineral Div. of Food Machinery and Food Corp. purchased some 130 acres of phosphate reserves in Rich County, Utah. **Western Phosphates Inc.** announced plans for a 50 pct increase in facilities to produce triple superphosphates and ammonium phosphates. Phosphate rock comes from the properties of **San Francisco Chemical Co.** in Wyoming, Idaho, and northeastern Utah. **American Sulphur & Refining Co.** acquired the sulphur deposit and plant at Sulphurdale, Utah, and is constructing a new $500,000 plant to produce 100 tons of refined crystalline sulphur daily, beginning January 1955. **The Ridge Development Co.** is drilling a residual bitumen deposit near Vernal, Utah, preliminary to building a plant to produce petroleum products from this deposit.

In the field of iron ore production and related processing in Utah, **Colorado Fuel & Iron Co.** has been developing a new open pit operation at its Iron Mountain properties in Iron County, Utah. **The U. S. Steel Corp., Columbia-Geneva Div.,** announced plans late in 1954 to construct a steel pipe plant and an anhydrous ammonia plant near Geneva, Utah, the latter to have 200-ton capacity of anhydrous ammonia and ammonium nitrate. Construction will begin early in 1955.

Copper production in Utah in 1954 will probably fall some 60,000 tons below 1953, due to voluntary curtailment and strikes. Additional plant and operational facilities planned, under way, or completed during 1954 are:

Kennecott Copper Corp. made several additions to its plants and facilities, including a $3.3 million improvement program in the Arthur and Magna mills; a $1.5 million addition to the electrolytic copper refinery to produce vertical castings and "cakes"; completion and dedication of the $1.25 million research center on the University of Utah campus; and centralization of engineering for the four western subdivisions of the company in Salt Lake City.

Garfield Chemical & Manufacturing Co. which produces sulphuric acid at the Garfield copper smelting plant of **American Smelting & Refining Co.,** plans an extensive acid storage plant at Thompson, Utah, to serve the uranium milling industry.

Lead and zinc production will be about the same as for 1953. The Tooele lead smelter, lead-zinc mill and zinc fuming plant of the **International Smelting & Refining Co.** closed down May 31, due to shortage of lead-zinc ore for treatment. The mill is now operating at partial capacity, because of the reopening of the **United Park City Mines Co.** mining operations. **United Park** has employed about 175 men, producing about 6000 tons per month. Since reopening, a high grade lead-silver orebody of undefined size was discovered on the 2100 level.

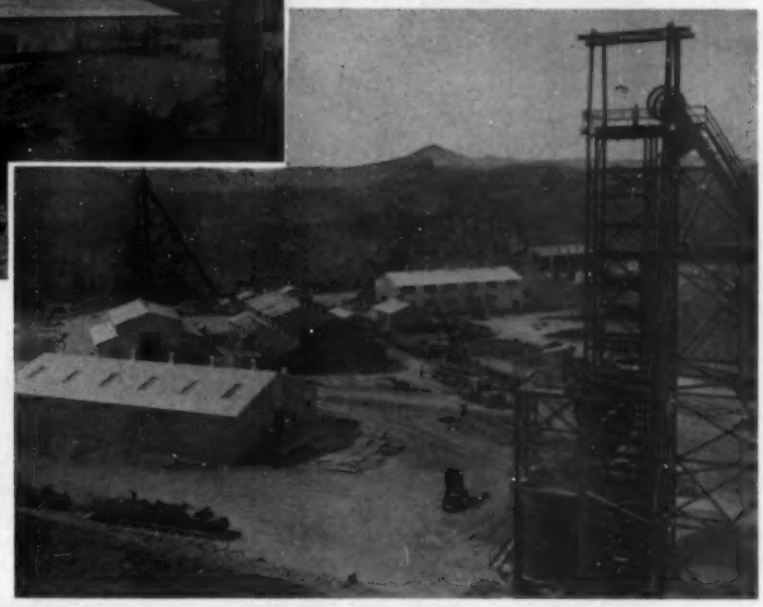
E. J. Longyear Co. have started diamond drilling at Eureka, Utah, on properties acquired under a "unit lease" arrangement obtained from **Chief Consolidated Mining Co., Tintic Standard Mining Co., United States Smelting, Refining & Mining Co.,** and others.

The Salt Lake Tungsten Co. reported receiving an increased volume of tungsten concentrates during the year. Discovery of commercial tungsten ore in the Alta mining district was claimed by the **Park Brighton Mining Co. The Consolidated Uranium Co.** announced plans to mine and mill tungsten on properties recently acquired near Gold Hill, Utah.

The Calera Mining Co. completed agreement in February with the **Chemical Construction Co.,** builders of the plant, to operate the cobalt refinery for a period of two years. Cobalt concentrates come to the plant from the Calera Mining Co.'s Blackbird mine in Idaho.

San Manuel Copper

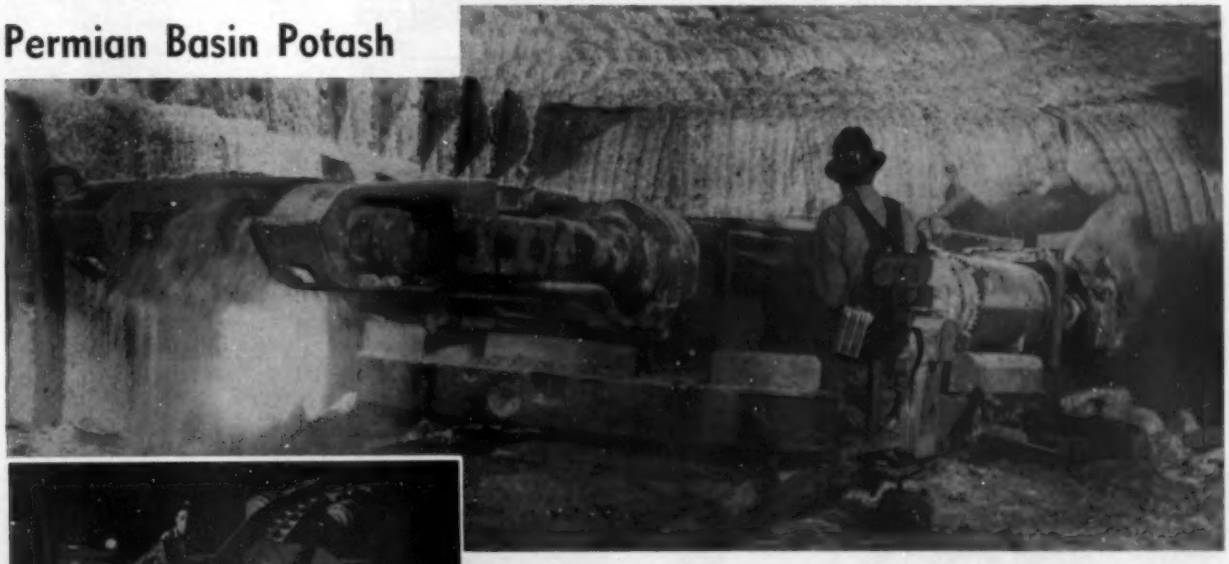
The San Manuel Copper Corp. project at Tiger, Ariz. scheduled to produce 30,000 tons of 0.8 pct copper ore per day is now under full scale development, with limited production set to start in 1956. During 1954 three major shafts were started. Two identical four-compartment shafts, Nos. 3A and 3B, located 195 ft apart will hoist the 30,000 tpd mine production. The surface installations for these two shafts is shown at the left.

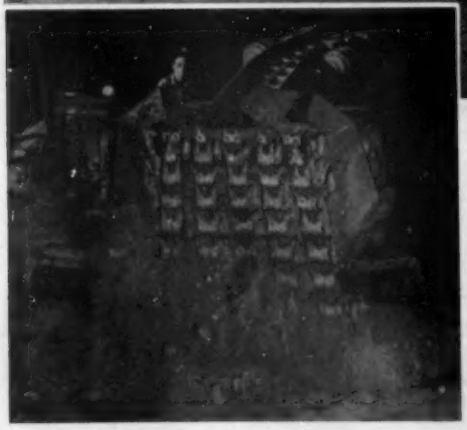


At the end of the year, both shafts were down to a depth of more than 1000 of the total depth of 1750 ft.
New surface installations for the mine have been constructed during the year. Permanent hoist houses and 1200-man change room will be completed in 1955.

No. 4 shaft, (Right) was completed in 1954, and will serve as the main development and service entrance for the mine.

Permian Basin Potash





First Joy "potash miner" specifically designed for mining in the Carlsbad Basin is shown (Above) cutting bottom for track bed and (Left) is cutting a low back. In comparison with other Joy continuous machines already in operation, the new model 1-PM is heavier, more powerful, and more sturdily constructed to meet the demands of continuous mining in the potash field.

Annual Review

Mining Geology and Exploration

Edited and compiled by Edward L. Clark

THE year 1954 witnessed great activity in the field of geology as applied to mining. The search for ore in nearly all districts is becoming more and more intensified as established reserves are being depleted. Much geologic work has been directed to finding extensions of known orebodies, but prospecting in new areas has constituted a large part of the program of many operators. The acute need for additional reserves has brought into the search all the tools known to the geologic profession. This is reflected directly by frequent references to geophysical and geochemical methods in the regional reviews that follow.

The lone prospector of the early days of metal mining has been eliminated almost completely by modern scientific methods involving surface and subsurface geology, exploratory drilling, geophysics, and geochemistry. Nearly all new exploration is based on long-range programs coupled with studies of regional geology to determine the structural environment of areas of mineralization. The success of this approach has encouraged new operators in the field of exploration to adopt similar policies. Only in the search for uranium ores is the individual prospector still active, but the familiar picture of the burro heavily loaded with grubstake, gold pan, and pick and shovel has been replaced by the Geiger counter and the scintillometer carried by hand, by truck, or by airplane.

Many mining men are well acquainted with the activities and programs of the U. S. Geological Survey, the U. S. Bureau of Mines, and the individual state geological surveys and mines bureaus. Others are not so well informed. In 1953 the state surveys conducted 781 investigations through the manuscript stage and published 387 maps and reports. It now appears that a comparable body of literature became available in 1954. It should be remembered that a vast amount of geological research by the state geological surveys is not published. Most states follow the practice of placing unpublished reports on open file where they can be examined and discussed with survey personnel. This reserve of mineral data should be mined by the mineral industry.

E. L. CLARK is Missouri State Geologist, Rolla, Mo.

Southeastern Appalachian District*

The southeastern Appalachian area has attracted appreciable attention from several major mining companies as a possible source of nonferrous metals, principally zinc. Comprehensive exploration campaigns have been in progress for some time, and at least three new areas are being developed and commissioned for production.

Exploration in the southern Appalachians is both difficult and expensive. Surface manifestations of orebodies are rare and many of the programs supplement geologic investigation with geochemical prospecting.

American Smelting & Refining Co. is diamond drilling near the New London copper mine 10 miles east of Frederick, Md., and is conducting reconnaissance examinations at other points in the southeast. A permanent exploration headquarters for the eastern half of the United States, under Deane F. Kent, has been established at Knoxville, Tenn.

American Zinc Co. of Tennessee developed two new mines during 1954 and explored a large unprospected area in the Mascot-Jefferson City district of Tennessee. One shaft was completed in the big South Friends Station orebody 4 miles southwest of New Market, Tenn., and a second was started near Jefferson City late in 1954. This mine is planned for use of the Hayes Gismo, a unit combining drill jumbo, mucker, and haulage equipment. Production will start early in 1955.

Prospect drilling with ten diamond drill rigs is being carried out in the large West New Market Exploration Project, an area of 12 sq miles. A term contract divides expenses of development between American Zinc Co. and DMEA. The government agency is to be repaid through royalties on the zinc concentrates that might be produced from this area any time during the next 30 years.

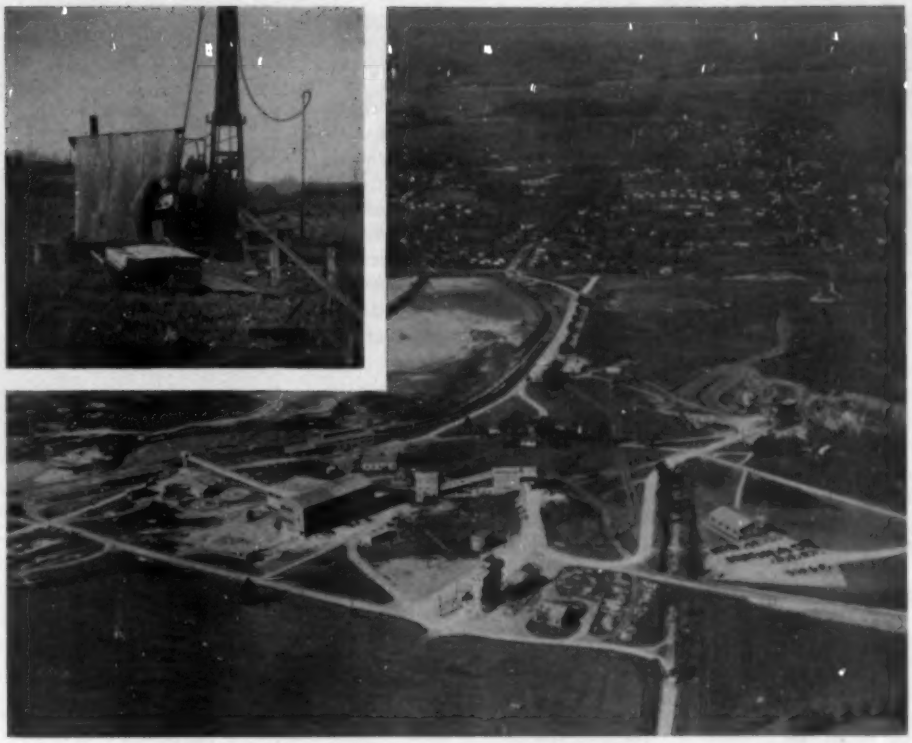
The New Jersey Zinc Co. carried on development and exploration in Virginia and Tennessee and geological reconnaissance in North Carolina, continuing a drift to connect the Austinville and Ivanhoe, Va., shafts and sinking a production shaft and a ventilation shaft at Jefferson City, Tenn. Preparations were made to dewater the old mine workings at Armenius, Va., in order to provide deep exploration bases. Other activities included geochemical surveys in Virginia and Tennessee, and diamond drilling in eastern Tennessee.

In the Shenandoah Valley near New Market, Va., **Tri-State Zinc Inc.** has been exploring for zinc during the past three years. In the Beekmantown formation drilling has revealed a small zinc orebody of a grade similar to the Tennessee deposits.

Tennessee Coal & Iron Div., U. S. Steel Corp., continued detailed geological investigations in eastern Tennessee and southwestern Virginia during 1954.

Results of exploration in other areas of Virginia and West Virginia were negative.

* The author is deeply indebted to Edward B. Jennings for assistance on this section.



GEOLOGY & EXPLORATION: Not large in scale or in manpower and often unseen, work of the geologist is vital to creation and continuation of mining areas similar to the one shown in this view from the Tennessee zinc district.

Metal Mining and Exploration in the New England States and New Brunswick

Joseph M. Trefethen

Metal mining in New England and the Province of New Brunswick does not bulk large, being far outweighed dollar-wise by the nonmetallics. Nevertheless, discoveries of large deposits of commercial grade lead-zinc-copper ores in New Brunswick have brought an exploration boom to the area and given new impetus to exploration in northern New England.

In **New Brunswick** large companies are carrying out intensive geological, geochemical, and geophysical exploration, and a vast number of claims have been staked throughout the province by large and small interests alike. The American Metal Co. Ltd. has recently announced a new major discovery in the lead-zinc-copper region. The Keymet mine, reported to be first in production, is the only one of the new discoveries now in operation and the only large metal producer in New Brunswick.

In the **New England States** production is limited to copper, gold, beryllium, and magnesium. Copper production is the chief of these and Ventures Ltd. is operating Vermont Copper Co. through a subsidiary, Appalachian Sulfide Co. Although no figures are available there is steady and substantial production, with a small byproduct of gold and pyrrhotite, and exploration activities have been stepped up. The pyrrhotite is shipped to Berlin, N. H., for conversion to acid by the Brown Co. Sinter from the roasters is stockpiled for possible use in the iron and steel industry.

Of the several companies exploring for metals in Vermont, The New Jersey Zinc Co. is said to have carried on an extensive geologic program. The U. S. Geological Survey is continuing structural and stratigraphic studies, and the Vermont Survey is intensifying its program of basic mapping.

The **New Hampshire** Survey reports that during the year at least four major companies in the field have conducted geological and geophysical surveys, with some trenching and drilling. Ventures Ltd. is said to be interested in the old Milan district, and The New Jersey Zinc Co. is reported active in field exploration. Ralph Meyers, state geologist, further states that the new geologic map of New Hampshire is approaching completion and that the State Survey plans airborne geophysical work.

There is no current metal mining in **Maine,** but Kennecott has been carrying on geological and geophysical exploration, and several other companies have been doing reconnaissance work. Most recent to enter the area with an intensive program is the American Metal Co. Ltd.

The province has made an aeromagnetic and scintillometer survey of some 800 sq miles along the New Brunswick border and in cooperation with the USGS has covered a large area in the western part of the state with an airborne magnetometer. The USGS has completed a wide reconnaissance by carborne and airborne scintillometer.

Federal agencies have further explored and drilled the large low grade manganese deposits (350 million tons) of Aroostook County. A pilot plant for recovery of the manganese by the Nossen process has been built in New Jersey.

In **Connecticut** magnesium is the only metal produced. The New England Lime Co. is reported to be operating the New Canaan plant at about 70 pct capacity. A minor amount of beryl has been recovered from feldspar operations, but there has been little exploration for metals in the past year other than examination of a few prospects by the U. S. Bureau of Mines.

There is no metal mining in Rhode Island or Massachusetts, but some geological exploration is being conducted in both states.

Information on which this report is based has been supplied by the Dept. of Lands & Mines of New Brunswick and by Ralph Meyers, Charles Doll, and John B. Lucke, state geologists, respectively, of New Hampshire, Vermont, and Connecticut.

(Review continued on page 242)

Tri-State District — Missouri, Kansas, and Oklahoma

Dan R. Stewart

In the search for new orebodies and extensions to existing mines, mining geology in the Tri-State district was seriously curtailed during 1954 because of low zinc and lead prices and the marginal nature of district ore occurrences. Only the U. S. Bureau of Mines, the Defense Minerals Exploration Administration, the Eagle-Picher Co., and the American Zinc, Lead & Smelting Co. have carried on concerted exploratory programs. Scattered exploratory drilling has been conducted by individuals and by small operators.

By far the greatest amount of geological work in the district has been done by the USBM, which has under way a cataloging project to compile all mine, drillhole, and ore reserve information for the entire mining field. When finished, the mine catalog will include a set of base maps showing all underground mine workings and surface drillhole locations. A complete microfilm library of all available drillhole logs is also planned. Portions covering the Picher and Baxter Springs areas are nearing completion.

The USBM zinc-lead exploration project in the Racine-Spurgeon area of Newton County, Mo., begun in December 1953, includes geological studies, geophysical surveys, and prospect drilling. In the mapping of subsurface zones of rock alteration in advance of drilling, 56 miles of electrical resistivity traverse lines were surveyed over an area of 3200 acres. To date 25 churn drillholes have been completed, but information is still too limited for appraisal.

DMEA had only one active project in the district during the past year, a program conducted by the Dale Mining Co. of Stark City, Mo., which is prospecting for possible mine extensions on the Patterson and Clark tracts in the Aroma area of Newton County, Mo. The ten completed drillholes in the lower portion of the Mississipian (Reeds Spring formation) have produced encouraging results.

Quick Seven open pit zinc mine, Jasper County, Mo., now closed down. The circular core is barren.

Eagle-Picher Co. limited geological activities during the past year to operating company properties lying in the Picher area. Three churn drills on the surface and several underground longhole percussion drills were used for underground mapping and drillhole prospecting.

With the closing down of the Quick Seven mine in May the American Zinc, Lead & Smelting Co. is now confining all geological activities to the Nellie B operation in the Picher field. The company is using a surface churn drill on mine extension work and two longhole percussion drills on underground prospecting.

The Mississippi Valley Area

Matthew P. Nackowski

Depressed base metal markets retarded geologic activity in the Mississippi Valley area. Exploration programs started earlier are being continued on a limited scale to protect committed investments.

Regional or district-wide geologic studies are in progress in the upper Mississippi Valley area and in the southeast Missouri lead belt. In the Illinois-Wisconsin-Iowa lead-zinc district, partial results of a program directed by the U. S. Geological Survey in cooperation with the Wisconsin Geological & Natural History Survey were published. In the southeast Missouri lead belt the geologic program under the direction of the St. Joseph Lead Co. was verified by previous geologic interpretations.

Wisconsin-Illinois-Iowa Lead-Zinc District

In **Wisconsin** the USGS in cooperation with the state is mapping the lead-zinc deposits of twelve 7½-min quadrangles as part of a comprehensive study in progress for several years. A report and a map of the area of past mining activity was published this year. The regional structural setting of the upper Mississippi Valley area was reported at the AIME Annual Meeting in February 1954.

The DMEA has participated in several contracts in the district that have resulted in mineral discoveries.

The **Illinois** State Geological Survey, continuing detailed structural mapping in the Illinois part of the district, has tried geochemical prospecting to delineate favorable areas for exploratory drilling. Soil samples have been analyzed for heavy metals with dithizone with largely negative results.

Operators in the district have contributed to the fund of geologic information about the district. The American Zinc, Lead & Smelting Co., Eagle-Picher Co., Tri-State Zinc Co. Inc., and Vinegar Hill Zinc Co. are active in this area.

Southeast Missouri Lead Belt

St. Joseph Lead Co. is continuing the systematic geologic study of the southeast Missouri lead belt started in 1947. Current work being carried out by 20 resident geologists includes detailed geologic mapping of the extensive mine workings. Data collected are used to guide daily development and mining work as well as provide information to shape exploration programs. Surface geologic mapping on a quadrangle basis is progressing as is churn and diamond drilling. These exploration holes are penetrating the basement rocks, and the data are used to develop a picture of the pre-Cambrian surface that underlies the district. Geophysical methods supplement other surface work. Underground diamond drilling is also used to probe the ore extensions and new orebodies.

A progress report published in March of this year outlined the problems highlighted by geological work done since 1947. These included the subdivision of the Bonneterre formation, which is the principal district ore-bearing formation, description and classification of the different structural environments of the orebodies, rock alteration, and ore genesis. In September a supplement was published to the progress report issued in March. Structures referred to as *fingers* and *rolls* in March and considered with reservations as alteration features and dynamic structural features were confidently identified as organic algal growths, and therefore primary sedimentary structures. Some orebodies are spatially related to the rolls; consequently recognition of their character was a significant step. Primary

sedimentary structures are more frequently recognized as loci for orebodies.

Some magnetic highs in the southeast Missouri lead belt have been tested by surface drillholes. Magnetite-hematite concentrations have been found to be responsible for these magnetic anomalies.

National Lead Co. has been active geologically in the vicinity of company mines near Fredericktown in the southeast Missouri lead belt. Subsurface structural mapping, geologic mine mapping, surface churn drilling, and diamond drilling are in progress. This work, together with geophysical work previously completed, was used to guide several hundred feet of development drifting each month.

Last spring the American Metal Co. Ltd. terminated its exploration program in the southeast Missouri lead belt. The work had included surface drilling.

Illinois-Kentucky Fluorspar-Zinc-Lead District

Geologic activity in this district was curtailed because of the adverse fluorspar market. Most of the geologic work this year was done by the operating companies. The Illinois and Kentucky geological surveys cooperated with industry but had no formal programs in the district.

Exploration diamond drilling and churn drilling programs are being continued by several of the mining companies. Geochemical methods, using dithizone analysis for heavy metals, are being tried. The companies engaged in geological work include Alcoa, Minerva Oil Co., Ozark-Mahoning Co., Penn Salt Co., Reynolds Aluminum Co., and The New Jersey Zinc Co.

Lake Superior Region

by Burton H. Boyum

Exploration activities in the Lake Superior region continued at a high level. A ten-year study of the Keweenaw copper area, completed by the U. S. Geological Survey in 1954, is being released in a series of topographic and geologic maps. The USGS has closed its Iron River, Mich., office and moved to Iron Mountain. It is also maintaining an office in Crosby, Minn., on the Cuyuna Iron Range.

A conference on Lake Superior geology at Hibbing, Minn., on April 9 was sponsored by the Minnesota Society of Professional Engineers and the University of Minnesota. The annual diamond drilling symposium, also sponsored by the University of Minnesota, was held at Minneapolis October 14 to 16. Another significant contribution has been the publication of the Minnesota Geological Survey Bulletin 38 by David White on the lithology and stratigraphy of the iron formation of the Mesabi Range, Minnesota.

There has been increasing interest in photo-geology; E. J. Longyear Co. has been very active, employing one man full time. Magnetic methods continued to be the principal technique of geophysical prospecting for iron, copper, and base metals in the Lake Superior region. The magnetometer and super-dip have generally replaced the traditional dip needle. A number of mining companies also cooperated with the Houston Technical Laboratories in the experimental studies using the high resolution reflection seismic technique.

Federal and state governments are continuing the program of aeromagnetic coverage and the Minnesota Geological Survey has placed additional aeromagnetic maps on open file. Little mention or application has been made of geochemical techniques. The district office of the AEC in Ishpeming, Mich., is carrying out research on the radiation characteristics of various rocks. (*See also Geophysics Review*)

Ralph Marsden of the Oliver Iron Mining Div., U. S. Steel Corp., reports a slight increase in core recovery and speed of drilling with the wireline core barrel developed by E. J. Longyear Co., the most significant contribution made during the year in the field of exploration drilling. Mr. Marsden also states the company has been using cementing practices more extensively during the past year. Alan Broderick of Inland Steel Co. reports research on taking oriented drill cores and Cleveland-Cliffs an increasing use of the bentonite base drill mud.

According to Thomas Broderick of Calumet & Hecla Copper Mining Co., studies have been made along the Kearsage amygdaloid and along the Knowlton lode near Mass City, both in the Keweenaw area, Michigan.

Rocky Mountain — Colorado Area

Robert H. Carpenter

Geological activity in the Rocky Mountain region of Colorado was restricted during the past year because of depressed prices in lead and zinc. Many former producers are shut down, and some of those remaining open are on an exploration basis rather than on a production basis. A feeling of optimism appears to be developing, however, and a stimulus in exploration activities may be in the offing in the lead-zinc districts.

San Juan Area

The Idarado Mining Co., above Ouray, has continued profitable production of moderately low grade, complex ores. Favorable developments at depth in properties formerly known as the Black Bear, Tomboy, Argentine, and Smuggler Union mines, now all consolidated in Idarado, will eventually mean reopening of the Smuggler mill at Telluride. Developments by Idarado both on strike and at depth in these old properties have rejuvenated the Telluride-Ouray district and have proved a vertical range of production in these Tertiary veins that formerly was doubted. This development offers promise for other properties in the San Juans.

Above Silverton, where the Pride of the West mine and mill continue to operate, limited exploration is in progress. The owners have taken over the nearby Osceola mine. The **Rico Argentine Mining Co.** has continued production and has expanded its development work to additional veins.

At Creede in the eastern part of San Juans exploration related to leasing activities in the **Emperius Mining Co.** properties has continued during the past year.

South Central Area

During the summer of 1954 the **Bear Creek Mining Co.**, a subsidiary of Kennecott, completed three exploratory diamond drillholes, 1820 to 2490 ft deep, in an area 5 miles south of the old mining camp of Bonanza in Saguache County. The object of this drilling in volcanic flow rocks was to prospect for orebodies in the underlying (?) Leadville limestone. The nearest outcrop of this limestone is some 4 miles to the south of the area drilled. None of the holes drilled penetrated the flow rocks. An evaluation of Bear Creek's work there is now under way. In addition to normal geologic practice, the following methods were utilized in gaining data: aerial color photography, geochemical soil testing, ground magnetics, gravity surveys, and electric and radiometric logging of drillholes.

Longyear's wireline rig was employed to drill the deeper of the three holes, with nearly 100 pct core recovery. A diamond saw (commercial brick saw) was used in core splitting to obtain representative samples for geochemical and petrographic study.

Reynolds Mining Corp., subsidiary of Reynolds Metals, has been operating a fluorspar mine some 4 miles southwest of Salida for three years. Extensive fluorite mineralization occurs in lenses and pockets along the major, easterly trending shear zone. Both surface and underground exploration are in progress.

Investigation of promising thorium and lithium deposits is under way in the vicinity of Powder Horn near Gunnison by the **Lindsey Chemical Co.** Occurrence of thorium in the vicinity of Westcliff is being studied actively by private groups as a follow-up to USGS studies.

Thorium-uranium mineralization is being investigated along the west flank of the Sangre de Cristo Range east of Villa Grove in the San Luis Valley.

Field studies have located uranium mineralization near Salida, Canon City, southwest of Colorado Springs, along the mountain front northwest of Denver, and in the vicinity of Walcott in Eagle County.

Central Colorado

Geologic activities at Leadville are restricted to studies by the **Resurrection Mining Co.** in Iowa Gulch on the south side of the district and to exploration in connection with leasing activities in the Resurrection No. 2 mine. The Ibex-Sunday Project of **American Smelting & Refining Co.** is inactive at present. With an improvement in the lead-zinc picture this and other exploration projects in the district probably will be resumed.

At Gilman deep level exploration based on data from previous geologic mapping, rock alteration studies, and geophysical and geochemical investigations is in progress. Further use of geophysics is anticipated. Diamond drilling is an effective underground tool to prospect specific targets.

At **Climax** deep level exploration based on petrographic studies of rock alteration and mineralogic relationships is being continued. Early this year the company established an exploration division, which will be active in the near future in the search for new properties in the Rocky Mountain region.

The Wellington mine at Breckenridge and the Buckskin mine near Alma have weathered low prices, and both mining and exploration are progressing. The Dixie mine near Idaho Springs is expected to reopen soon. Plans have been laid to reopen the long Argo tunnel driven from Idaho Springs northward under Central City.

Exploration based on results of geologic and geochemical studies is in progress at the Urad molybdenum mine, southwest of Berthoud Pass in Clear Creek County. This deposit is similar in many respects to the one at Climax.

The Molybdenum Corp. of America is exploring the Questa molybdenum property a few miles east of the town of Questa in northern New Mexico. This high grade deposit is situated on the west flank of the Sangre de Cristo mountains a short distance south of the Colorado border in an area of granite intrusives.

The Southwest

Harrison Schmitt

Activity in applied mining geology and in exploration increased in the Southwest during 1954, with emphasis on exploration for copper, uranium, and potash. Work on lead, zinc, gold, silver, and fluorite ore deposits reached a lower ebb than at any time in 15 or 20 years. There has been new minor activity in barite, manganese, and tungsten.

Intensive search for new copper orebodies, especially in Arizona and particularly for the disseminated type, has not had the publicity given uranium prospecting, which resembles the Yukon gold rush. Nevertheless, for several years copper exploration has been carried on by several hundred engineers and geologists.

Conventional geologic and engineering tools have been chiefly used, but applied geophysics and trace-element sampling have played important roles. Effective integration of geology and applied geophysics may not be far off. The effect of this trend can already be seen in the Southwest. The work of United Geophysical Corp. at the Pima mine in Arizona (Ref. 9) is a good example of such integration. True geochemistry as distinguished from trace-element sampling is being used with success in solving theoretical and practical problems in mining geology in the Southwest.

New Mexico

The New Mexico Bureau of Mines & Mineral Resources at Socorro, N. M., has been expanded notably in the last five years. Under the direction of Eugene Callaghan, it is conducting research in the application of mining, geological, and engineering principles to all mineral, fuel, and water resources. This bureau, together with the College Div. under William Hume and the Research & Development Div. directed by E. J. Workman, constitutes the New Mexico Institute of Mining & Technology. Mr. Workman is also director of all three departments. The organization is unique for a western state and calls to mind the mineral resources program of the Illinois State Geological Survey Div. developed by M. M. Leighton. The personnel, the work being done and planned, the facilities and equipment, and above all the esprit de corps are stimulating.

Work of the regular staff includes area geologic mapping, recording of mining and petroleum activity, laboratory testing and research, and preparation of reports. Graduate students and qualified geologists are assisted, particularly in making geologic maps and regional and local geologic studies. Current activity of this nature includes the mapping of a substantial part of the Zuni Mountain area. Part of this work

NEW MEXICO: View at left is of surface plant, Southwestern Potash Co., Carlsbad, N. M. At right, the Santa Rita pit, which is being expanded to devour the *island* on which there are still some houses and offices.

ARIZONA: Left, the mill at Christmas has been rebuilt by the Allison Steel Co. at this old copper mine under active development by Anaconda. At right is the Banner Mining Co. property at Mineral Hill, west of the new Pima mine.

appears in Clay T. Smith's *Geology of the Thoreau Quadrangle*, a New Mexico Bureau of Mines bulletin published in 1954. The area includes part of the Grants uranium district.

The staff, along with the geology dept. of the State University, is cooperating with the USGS Fuels Branch in the compilation of a new state geological map. The northwest part is nearly completed. Vincent Kelly, of the geology dept. at the State University, in cooperation with the USGS and the University of New Mexico, has recently published a tectonic map of the upper Rio Grande area.

Numerous uranium orebodies have been discovered by use of geology, applied geophysics, and enlightened prospecting. E. C. Anderson, mining engineer for the bureau, has been compiling and publishing data on the uranium occurrences in New Mexico.

In the Central mining district, New Mexico, **Kennecott Copper Co.** has succeeded in expanding the limits of its disseminated copper orebody. Research on rock alteration at Santa Rita is being conducted by Keith Martin, who recently collaborated with G. Ordonez and W. W. Baltosser in new structural mapping of this area. The results of this work were presented to the AIME at New York in February, 1954. Phelps Dodge Copper Corp. is drilling a porphyry copper deposit at Tyrone, N. M.

The New Jersey Zinc Co. has found that the Lower Blue horizon of the Lake Valley limestone contains much more important zinc ore mineralization than had previously been known. Total reserves are said to be impressive. This discovery has encouraged the sinking of a new main shaft near the present mill. Other zinc mines of the area have ceased producing.

In the **Carlsbad potash area** production expansion continues as new companies enter the field. The methods of exploration, mining, ore handling, and refining used in this area are outstanding examples of modern enterprise at work. The development, production, and milling of uranium by companies and individuals in Arizona and New Mexico is no less praiseworthy.

Castle Dome as it appears today from the south. Mining and milling equipment have been moved to Copper Cities, north of Miami, Ariz.

Arizona

The Arizona Bureau of Mines in cooperation with the USGS is starting a revision of state topographical and geological maps, expected to take three years.

The USGS is carrying on several additional projects in Arizona, including a continuation of the long-term study and mapping of the Globe-Miami copper district by Nels Peterson. A study of the uranium deposits in the younger pre-Cambrian rocks of the Sierra Ancha area in central Arizona was started by H. D. Granger in June 1954. Regional studies related to asbestos deposits of the same area are being continued by A. F. Shride. Medora Krieger is continuing her studies in the Prescott pre-Cambrian area and S. C. Creasey has begun long-term study of the San Manuel district.

The USBM office for New Mexico and Arizona is chiefly active in passing on and periodically checking DMEA and old DMPA projects.

In Arizona the Ground Water Div. of the USGS, under Leonard Halpenny, has a staff of about 50, including 16 geologists. Arizona is faced with a difficult ground water depletion problem, particularly because a large proportion of farm irrigation is from wells. Some aquifers are being depleted at ten or more times the natural rate of recharge. Studies of the Navajo and Hopi Indian reservations by J. S. Harshbarger are soon to be completed by the Ground Water Branch. The resulting maps will be of interest to mining and petroleum people.

The U. S. Bureau of Indian Affairs is continuing the mineral resources survey, directed by George Kiersch, of the Navajo and Hopi reservations.

Private enterprise, particularly by the large mining companies, has been active in geological investigations and in exploration. The theory and practice of mining geology has received considerable attention from students and writers in the Southwest in 1954.

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The Pacific Northwest

Oregon — Fay W. Libbey

Investigations of the Oregon Dept. of Geology & Mineral Industries have disclosed ferruginous bauxite deposits of substantial thickness in the Salem Hills south of Salem in Marion County. Field work has shown thickness in places of more than 20 ft of gibbsitic laterite. It appears that the quantity and quality of material in the Salem Hills will compare favorably with the deposits explored by Alcoa in Washington and Columbia counties farther north.

The laterized material in the Salem Hills, including the bauxitic section, is associated with Stayton lavas of probable Miocene age which are correlated with the Columbia River basalts. Stayton lavas lie unconformably on Oligocene marine tuffaceous sandstones and pebble conglomerates called the Illahe formation, correlated with the Eugene formation.

Presence of the bauxitic section of the laterite capping the higher topographic areas indicates that laterization was restricted to the uppermost flow or flows. Gibbsite nodules, scattered widely throughout the thin soil zone, may constitute an important *sweetening* material because of their high Al_2O_3 content (about 60 pct).

The arithmetical average of the bauxitic section determined from work done so far is as follows: Al_2O_3, 35.4 pct; SiO_2, 9.7 pct; Fe_2O_3, 29.1 pct; TiO_2, 5.9 pct; loss on ignition, 19.9 pct. The percentage of TiO_2 in the bauxitic zone, ranging from 2.17 to 9.32 pct, apparently is associated closely with the amount of iron, since analyses show a fairly constant $Fe:TiO_2$ ratio of 3 to 1. Panned concentrates of the bauxite indicate that a very small percentage of titaniferous magnetite and ilmenite is present, but the principal titanium minerals have not yet been determined definitely. In other laterized basalt areas, however, anatase is the predominant titaniferous mineral.

To determine prospecting criteria for the occurrence of chromite and for continuity of the pods of massive ore, the Oregon Dept. of Geology & Mineral Industries continued investigation of occurrence in the ultra-basic rocks of southwestern Oregon. Geologic mapping on a scale of 1:15,000 was completed for two areas with numerous chromite prospects and the prospects were mapped in detail. In cooperation with the state department the USBM has done reconnaissance exploration of nickel laterite occurrences in the ultrabasic rocks of southwestern Oregon. A report of the work on the Red Flat nickel deposit of Curry County has been issued as RI 5072.

Washington

Sheldon L. Glover

Investigations have been carried on actively during the past year in various parts of Washington by the USGS and the state Div. of Mines & Geology. Particular attention has been given to the northern part of the Cascade Mountains and adjacent region, south from the international boundary to about the south boundary of King and Kittitas counties. This includes that part of Washington where mineralization is most prominent and widespread and where mining has always been most active.

The USGS has continued its investigation of the Metaline zinc district of Pend Oreille County. In addition, mining geology was undertaken in four 7½-min quadrangles in a well-mineralized area of adjacent Stevens County.

The Federal survey has been currently mapping in the Holden quadrangle, where the Howe Sound Mining Co. has one of the largest mining operations of the Pacific Northwest.

The state Div. of Mines & Geology has conducted investigations of mining geology in widely separated areas. Both newly discovered mineral occurrences including manganese and uranium and old, little-known deposits have received attention.

Alaska

Phil R. Holdsworth

Geologic field work and supplementary investigations of mineral deposits in Alaska are conducted by the USGS, USBM, and Territorial Dept. of Mines.

During 1954 the USGS operated 17 field parties throughout the Territory, examining the possibility of uranium in various mineral deposits and investigating tin deposits on the Seward peninsula. General geologic surveys were made in the Nushugak Valley, the Glacier Bay area, the north slope of the Nutzotin Mountains, and the southern half of Prince of Wales Island.

To supplement this field work the USBM employed both diamond drilling and geophysics for detailed exploration of deposits of tin, lead, and fissionable material on the Seward peninsula; tin and columbium in the Tofty area; copper deposits along the Landlock fault area in Prince William Sound; magnetite-copper deposits on Prince of Wales Island; and cobalt-lead-zinc mineralization on Manley Hot Springs dome.

The Territorial Dept. of Mines acts in a liaison capacity between the prospector or miner and investment capital. Preliminary field work accomplished by the department has, on occasion, justified specialized investigations by the USGS and the USBM.

California, Nevada, and Baja California

James L. Bruce

In view of the character and extent of geological services to the metal mining industry, it might appear that metal mining is lagging behind the petroleum and nonmetallic industries in its use of geology. In California value of metallic raw material products at their primary stage is not more than 4 pct of the comparable value of all inorganic raw material products, including petroleum, gas and other fuels, cement, clay, sand, gravel, and other nonmetallic mine products. It is evident that the net revenues from the metal mining industry are relatively small and unable to support more than a small percentage of the total geologic program. It seems probable that this industry is employing its fair share of geologic talent and receiving its fair share of state and federal geologic aid.

In California there is effective cooperation between the state Div. of Mines and the USGS. Both these agencies and many of the staff geologists of the universities and colleges are intimately in touch with metal mining. Consulting geologists, mine examining engineers, and resident mine geologists are greatly dependent on federal and state publications. California geologic programs to aid the metal miner include field work studies and mapping undertaken by the Mineral Deposits Branch of the USGS under cooperative agreement with the state Div. of Mines. During 1953 and 1954 this program covered copper-zinc in Shasta County, lead-zinc in Darwin and Ubehebe Peak districts, Inyo County, and tungsten near Bishop and in the eastern Sierras, Inyo County. A geologic report in process covers the Bully Hill-Rising Star area, Shasta County.

Amador County mineral resources have been described in the *California Journal of Mines and Geology*, v. 50, no. 1. In recent years the only important metal production has been gold. During 1953 the Div.

of Mines issued Special Report 28 on the Mammoth mine, Special Report 29 on the Afterthought mine in Shasta County, and Special Report 34 on the Santa Rosa lead mine in Inyo County.

Publications of the Dept. of Natural Resources, Div. of Mines, include *Mineral Information Service*, published monthly; the *California Journal of Mines and Geology*, published quarterly; the *Annual Report of the State Mineralogist;* bulletins; and special reports.

Reports in press include bulletins on the geology of southern California, Barstow quadrangle, and special reports on Calaveritas, Angels Camp, Sonora, and Ubehebe Peak quadrangles. Progress has been made on the Matterhorn Peak, Shoshone, and Tecopa quadrangles. A general review of the lead and zinc deposits of California has been prepared for publication.

Tungsten ranked first in value among the metals produced in California in 1953, followed by **iron ore,** then **gold.** Tungsten deposits of Madera, Fresno, and Tulare counties are described in Special Report 35 of the Div. of Mines. Tungsten in southern California is covered in Bull. 170, Chap. 8, in the paper by Paul C. Bateman and William P. Irwin. Geologic mapping of the important tungsten areas near Bishop and in the Casa Diablo Mountain quadrangle, including the Black Rock tungsten mine, has been made available to prospectors and operators. A noteworthy discovery has been made at the Brownstone mine near the U. S. Vanadium concentrator in Inyo County.

The history of **quicksilver,** with special emphasis on California production, has been given in *De Argento Vivo*, published as a supplement to the October 1953 issue of the *California Journal of Mines and Geology*.

Principal quicksilver producers are the Abbot mine in Lake County; the Juniper, New Idria, and North Star in San Benito County; La Libertad, San Luis Obispo County; the Guadalupe, Santa Clara County; and the Cloverdale, Culver-Baer, and Mt. Jackson, Sonoma County.

Exploratory operations at the Cloverdale, Culver-Baer, and Wall Street mines are described in *Mineral Information Service*, v. 7, no. 9, of September 1954. Operations at the Abbot mine, Mt. Jackson mine, New Idria mine, and others are described briefly in the October issue.

DMEA exploration programs on quicksilver have been carried on at Mt. Diablo mine in Contra Costa County, the Walibu mines in Kern County, Abbot mine in Lake County, New Almaden in Lake County, and New Idria in San Benito County. An important discovery was certified at the New Idria.

Discovery of a new high grade quicksilver orebody was reported at the California Quicksilver Mines Inc. property near Williams in Colasa County, operating under DMEA contract. Quicksilver deposits and occurrences in Lake and Santa Clara Counties are described in the April 1954 issue of the *California Journal of Mines and Geology*. The state Bull. 166 describes the geology of Lower Lake quadrangle, including quicksilver occurrences.

A list of all active DMEA programs in California is published in *Mineral Information Service* of May 1, 1954, which contains a map showing locations. Under this program exploration work was being carried on at seven properties containing the base metals **copper, lead,** or **zinc.** Certificates of discovery were issued for two of these projects, the Copper Hill in Amador County and the Defense mine in Inyo County. Work was still being carried on at the Donner and Penn Copper mines in Calaveras County, the Copper Bluff mine in the Hoopa Indian Reservation in Humboldt County, the Red Cloud in Inyo County, and the Bully Hill in Shasta County.

At the Bully Hill, an active producer during World War I, four drillholes were put down to depths of about 2000 ft. Drilling was very difficult and core recovery unsatisfactory, but ore showings encouraged owners to discontinue drilling in favor of an underground development program.

Geologic study of iron ore deposits was stimulated by the expanded activities of Kaiser Steel Corp. and by iron ore shipments from Pacific Coast ports. Chap. 8 of the state Bull. 170 describes iron ore deposits as well as base metal deposits of southern California. An exploration program was started at the Bessemer Iron mine in San Bernardino County under DMEA contract.

Production of **uranium** was initiated with a shipment from the Miracle mine of Miracle Mining Co. northeast of Bakersfield in Kern County. Discovery of uranium near Rosamond in Kern County was geologically described in state Div. of Mines Special Report 37. General information about the geology and mineralogy of uranium is published in *Mineral Information Service*, v. 7, issued July 1, 1954, by the state Div. of Mines. Sixty occurrences of radioactive minerals are listed, with a map showing locations, in the October 1954 issue of *Mineral Information Service* which also describes briefly the Miracle mine occurrence. Development work is still too limited to permit reliable prediction of the importance of California deposits.

Some geological efforts have been directed towards occurrences of the **rare earth** elements. At the large deposit of bastnasite and other rare earth minerals near Mountain Pass in San Bernardino County operations on a considerable scale are being conducted by the Molybdenum Corp. of America.

The USGS is carrying out a broad study of the stratigraphy and structure of the Mojave Desert.

Nevada

In Nevada exploration for metallic ore deposits was active this year, with considerable assistance from DMEA programs and geological services by USGS and the Nevada Bureau of Mines.

The USGS is engaged in a long-range study of the Eureka lead-silver district, where the mapping of one quadrangle is completed and mapping of another is under way. Geologic mapping is nearing completion for the Osgood Mountains quadrangle, an area that is of interest because it contains the Getchell gold mine and important tungsten deposits.

Field work in the Antler Peak quadrangle is complete and a USGS report is in preparation. Reports of the Pioche district (lead-zinc) and Ione-Paradise Peak quadrangle (quicksilver and gold) are being prepared.

An appraisal is being made to ascertain potential sources of uranium in siliceous volcanic rocks of the Jarbridge quadrangle in northern Nevada. Reconnaissance studies of uranium deposits in northern Humboldt County have also been made.

Field work in the Steamboat Springs area south of Reno is complete, and results including maps of the Mt. Rose and Virginia City quadrangles are being prepared for publication. The Virginia City quadrangle includes the mines of the fabulous Comstock lode. Important data on hydrothermal alteration and a better understanding of the relations of hot spring activity to ore deposition resulted from this study.

Geologic examination and mapping programs have been carried out by corporation staff geologists or by consulting geologists in connection with several tungsten operations, including those of the Lincoln mine of Black Rock County near Tempiute, the Garnet Tungsten Mining Co. in Elko County, and the Nevada Scheelite Div. of Kennametals about 54 miles southeast of Fallon where extensions of the mineralized ore zone have been proved. At the Linca mine near Austin operations were initiated with concentrate production.

At Ely Valley mines near Pioche exploration is in progress, with DMEA assistance, to find orebodies beyond the fault which terminated the principal orebody on its northeastward extension. A discovery of high grade silver-lead-zinc ore on the 500 level of the old Bristol mine near Pioche has been announced.

At the Mount Wheeler mines geologic mapping has been done on the claims held by the company. A long crosscut adit has been started to reach the intersections of persistent mineralized lodes with deepseated lime-

stone beds, which have been favorable host rocks in several localities in the state. Some tungsten ore was encountered and shipments made. The adit is being continued to reach other fissures.

Exploration programs have been directed at geologic targets in the Eureka district at the Adams Hill property of Eureka Consolidated and at the Consolidated Eureka Mining Co. property where good lead-zinc-silver ore was found during operation under DMEA programs.

In the Tonopah district at the Summit King mine considerable exploration work was done under lease-hold by Homestake Mining Co. and Summit King Mines. Ore was developed and shipments made, but not in satisfactory quantity. It has been reported that Calumet & Hecla Inc., owners of the property, will continue to explore at great length.

In the Silver Mountain mining district of White Pine County discovery of high grade lead-gold-silver ore by Grand Deposit Mining Co. has been reported.

The search for uranium has been aggressive, with discoveries reported about 77 miles northwest of Winnemucca in Humboldt County, on Kings River, and in Lander County.

Baja California

The most important geologic contribution of the year probably is the paper by Edward Wisser, "Geology and Ore Deposits of Baja California, Mexico," published in the January-February 1954 issue of *Economic Geology*. The author's summation of other writings and conclusions, added to his own knowledge of the terrain bordering the Gulf of California, will be useful in any mine exploration program in Baja California. Currently there is little exploration other than the activities of Fomento Minero de Mexico and Cía. Minera Las Cruces, S. de R. L., in the mineralized zone lying south of the town of El Triunfo, 33 miles south of La Paz in the southern end of the peninsula. Operations at the important Boleo Copper deposit at Santa Rosalia were discontinued early this year but a new firm, Cía. Minera de Santa Rosalia S.A., has been organized for the purpose of resuming operations.

Mining Geology in Mexico

William J. Shedwick, Jr.

The lure of still undiscovered deposits or overlooked bonanzas in the Antiguas of the colonial Spaniards is felt not only by the traditional prospector but by technicians as well. It is true that the early Spaniard's method of search for the precious metals left few outcropping deposits unexploited, but lack of suitable pumping equipment left primary ores of many properties virtually untouched.

It would be unjust to belittle the early miner's "nose for ore," but it still can be said that the entire Republic is ripe for years of comprehensively planned geological studies. With few exceptions the large operating organizations are smelting or beneficiating companies exploiting their major sources of supply, and these companies are currently supporting programs of geological studies, drilling, and exploration to assure their future requirements and protect their large investments. Unfortunately the extent and result of such programs are not open to the public, and there remains for the present discussion only investigations made by the smaller companies.

The mining industry in Mexico, like all others, has both suffered and benefited by devaluation of currency. Temporarily, the sale of metals and minerals in dollars at the new rate provides more money for payrolls in pesos, but overnight the prices of all imported machinery and supplies rose to a parity, and both rising wages and cost of local products will soon close the gap.

It would be useless to deny that the tax situation has been a heavy burden on the mining operator and a deterrent to the investment of foreign capital. This has discouraged the first step in such investment—geological studies. The fact is that until recently the mining industry was the largest privately owned business in the Republic and, as the Government budget must be obtained somewhere, the mines were the source. Over the past ten years, however, countless manufacturing plants have sprung up. Mexico is becoming industrialized and increasingly self-sustaining. In recognition of this the Government is drafting a revision of the mining tax laws. A revised application of the production tax and an appreciable reduction in the *aforo* (export tax) would influence all investors favorably, whether Nationals or foreign, and prove an incentive to geological studies and exploration. Changed tax laws would assure a fair profit to the operator, employ more men by increased production, increase instead of reduce the Government take, increase the country's ore reserves by placing large tonnages of low grade ore in the profit classification, and provide an opportunity for the mining geologist to demonstrate his essential part in the mining industry. *(Ed. Note: See* MINING ENGINEERING, *February 1955, p. 127.)*

GOLD—Mexico has never been known as a gold country, but the total amount of gold produced by three high grade mines and recovered from silver, lead, zinc, and copper mines can hardly be ignored. The Tayolita mine in Durango, the Cía. Minera Guadalupe at Mescala, Guerrero, and the Natividad mine in northeastern Oaxaca are currently exploring ahead of development and mining. In the Natividad mine diamond drilling is far in advance of acutal development because of the difficulty of maintaining openings in the slate formation for any length of time.

In Guanajuato at the Mina La Luz on the Veta Madre, the Comisión de Fomento Minero is dewatering the workings to a depth of 600 m to study and sample a vein reported years ago to contain good values in lead, zinc, and copper. This work may disclose some interesting data on vertical zoning in the district.

LEAD, SILVER, AND ZINC— Lack of space and the reluctance of the larger companies to publicize their findings prevents a just discussion of these metals. Despite the tax handicap, the slight improvement in the price of lead during the year was sufficient inducement for considerable exploration in many properties, both large and small. A new road down the arroyo northwest of Zimapan, Hidalgo, has provided access to a number of properties and will facilitate diamond drilling in search of suspected orebodies. The Comisión de Fomento Minero is preparing to drive under oxidized lead orebodies in the Cordonal property near Ixmiquilpan, Hidalgo, anticipating their continuation as sulphides. Cía. Minera de San Martin S.A. near Sombrerete, Zacatecas, has diamond drilled with satisfactory results over 10,000 ft in search for new orebodies and continuation of those known.

It is understood that Eagle Picher is actively exploring newly acquired Naica property in Chihuahua and that the American Smelting & Refining Co. has been active on properties near Cosala, Sinaloa. At Huautla, Morelos, the Cía. Explotadora de Minas S.A. is preparing to diamond drill 9000 ft in search of probable nonoutcropping orebodies.

GEOLOGISTS IN MEXICO appear to find the greatest problems economic, not technical—but work persists. Older properties continue to find new ore in some of the richest ore zones in the world. At right, Cía. Minera de San Martin; at left, Natividad, Oaxaca.

COPPER—At Mexico's largest copper producer, Cananea Consolidated Copper Co. in Sonora, present extraction is entirely from low grade (less than 1.0 pct Cu) orebodies, but the company persists in a program of drilling in search for more high grade bodies similar to those on which the exploitation was started.

Two possibly large, low grade copper deposits in southern Mexico are waiting thorough investigation. Detailed geological studies have commenced at one and probably the other will be explored in 1955.

MERCURY—The nearest thing to a rush in Mexico of recent date has been the intense interest in mercury because of the spectacular price rise. Practically every known deposit worked during the last two World Wars is now being re-exploited. Many others have been added to the list. Most of the deposits are small and many are covered by a multiplicity of denouncements belonging to different owners. As is customary in Mexico with this type of deposit, exploration, development, and mining become as one, and formal geological studies are seldom considered.

ANTIMONY—This metal has been in the doldrums for more than a year, and the present outlook is no more promising. Although there are many small antimony mines in Mexico, few of them are operating. The principal purchaser and refiner of this metal is the Texas Mining & Smelting Div. of the National Lead Co. through its Mexican subsidiary Cía. Minera y Refinadora Mexicana S.A. Both the smelter in Laredo and the large mine of another subsidiary, Cía Minera de Oaxaca S.A. in Oaxaca, are on a standby basis. Nevertheless, confidence in the future is evidenced by recent acquisition, following a thorough geological study of additional small groups of deposits in the Soyatal area of Queretaro.

IRON ORE—Since it is the policy of the Secretario de Economía to conserve iron for future domestic use, the incentive is lacking to explore extensively the many known but generally small deposits in the Republic. Occasionally an export permit is granted for a limited time and tonnage, seemingly to prevent a complete loss of interest. The Cía. Minera de Piscila S.A. is exporting from its deposit near Colima and continuing with diamond drilling in search of additional lenses of magnetite. Economía is now drafting a new set of regulations applicable to exploitation of iron deposits.

TITANIUM—A recent discovery of rutile near the west coast of Oaxaca has provided Republic Steel Corp. an opportunity to try out its technical staff on some knotty problems in both geology and exploration. (*Ed. Note: See* MINING ENGINEERING, *February 1955.*)

MANGANESE—Although Mexico has been contributing only about 5 pct of U. S. manganese consumption besides supplying its own needs, this amount has come from a large number of small producers. Contributing deposits are located principally in the higher central plateau region from the U. S. border south into the state of Oaxaca. A gambusino system of mining is usually followed and no attempt made to explore or develop much ahead of actual extraction. Two exceptions to this are the Autlan district in Jalisco southwest of Guadalajara and the Parian district near Nochixtlan, Oaxaca. By extensive diamond drilling in relatively horizontal bedded deposits in the Autlan district, U. S. companies found acceptable metallurgical ore. In the Parian district, limited diamond drilling by Manganesos del Centro S.A. in unique residual deposits in limestone has disclosed that these contain commercial ore to a depth of at least 50 m. The extreme fineness of this ore complicates marketing.

While it was in force the U. S. Government purchasing program for low grade ore for its stockpile in El Paso, Texas, was a boon to those producers who could not meet the minimum requirements for metallurgical grade. Practically all this production was from already known and previously worked deposits, and no geological studies or exploration was necessary to obtain the ore needed. As this article is being written the cancellation of the contracts, the drop in demand for manganese in the steel industry, and the influx of good but low-priced ore from India has seriously reduced production in Mexico.

PHOSPHATE EXPLORATION—Mexico is in great need of low-priced phosphate for agricultural use, but studies by the Comisión de Fomento Minero have not as yet disclosed deposits approximating those in the United States either in quantity or quality. In northeastern Zacatecas near Concepción del Oro relatively narrow beds of subgrade material have been found in Upper Jurassic sediments. Studies made by the USGS with the collaboration of the Comité Directivo para Investigación de los Recursos Minerales de Mexico are being augmented by work of the Comisión de Fomento Minero to exploit the deposits and beneficiate the phosphate to commercial grade.

Small, cavity-filled deposits are being exploited in both Tamaulipas and Nuevo Leon for an additive to cattle feed. In the Nuevo Leon deposits preparation is being made for diamond drilling exploration.

URANIUM—Whereas in the United States there has been a veritable gold rush for uranium-bearing minerals, in Mexico the search has been carried on in a desultory manner by individuals with limited financial backing. There has been no report of large companies participating. The Mexican Government has wisely protected by law the exploitation of uranium deposits. Discoverers and operators, however, do not have the freedom enjoyed north of the border. The limited activity is due more to the apparent lack of economic deposits than to stringency of the laws.

Developments in African Metal Mining in 1954

Thomas C. Denton

The African mineral industry, which has grown significantly since World War II, is probably more diversified than on any other continent. Many commodities supplied principally by Africa must be omitted here, as security measures and company restrictions greatly limit the release of data.

PLATINUM—A unique development in platinum mining is taking place in Africa through the establishment of large production from ore mined essentially for platinum group metals alone. Produced by Rustenburg Platinum Mines Ltd., the platinum metals come from the Merensky Reef in the Rustenburg district of the Transvaal. In round figures the company produced 299,000 oz of platinum group metals from the Reef in 1953. A somewhat larger figure is expected for 1954. The 1953 production compares with 191,000 oz produced in 1951 and 87,000 oz in 1949. The average analysis reported for 261,710 oz sold in 1953 is shown below:

* Metal	Pct
Platinum	66.27
Palladium	26.40
Iridium	0.13
Osmium and osmiridium	0.11
Rhodium	2.39
Ruthenium	1.35
Gold	3.35
Total	100.00

* Published by permission of the Director, U. S. Bureau of Mines.

A sharply defined ultrabasic dike dipping about 17°, the Reef is approximately 20 ft thick. Because the platinum content is essentially confined to a width of a few inches on the hanging wall, stopes are carried as narrow as possible, averaging 36 in. Ore shoots are remarkably persistent along both the strike and the dip, as illustrated by the fact that the company now mines about 1.5 million tons a year despite the narrow stopes.

GOLD—The Virginia gold mine in the new Orange Free State gold field of the Union of South Africa came into production early in October. It is the eighth mine in the field since October 1951, when the St. Helena poured its first brick. Production in the field increased during 1954 from 53,067 oz in January to 98,896 oz in September. Partly as a result of the Free State development, the Union's total gold production in July reached 1,126,206 fine oz, valued at the equivalent of about $39.1 million U. S., the largest quantity recorded in many years and the highest monthly value yet reached by the industry.

Several excellent papers on miscellaneous aspects of African gold mining appeared in *Optima*, a quarterly review published by Anglo American Corp. of South Africa Ltd. Perhaps the most interesting of these, "A View of Faulting in the Orange Free State," by B. B. Brock, includes four large paintings by G. A. Campbell depicting the supposed evolution of the Witwatersrand Basin. In so far as the writer is aware, these are unique among scientific geologic illustrations.

MANGANESE ORE—Africa produced roughly 2.3 million metric tons of manganese ore in 1953. In 1954 several new orebodies were found or indicated and established production capacity was somewhat increased.

In the Union of South Africa exploration and blocking out of ore begun in 1953 continued in 1954 on an extensive scale in some 30 miles of overburdened country lying between the north end of the Postmasburg field and the Black Rock deposit of Associated Manganese Ltd. The campaign includes geophysical surveys, diamond drilling, and underground development. According to report several million tons of new ore will be added to the very large reserves already established for the area.

Late in 1953 Beceka Manganese built a washing plant at its principal Kisenge mine in the Belgian Congo. With supplementary production of direct shipping ore, the installation was expected to yield the annual 250,000 metric tons originally planned for this project. Exports during the first half of 1954 totaled over 100,000 metric tons.

In 1945 an engineer of the French Colonial service first recognized that a very large area of manganese outcrops exists near Franceville, French Equatorial Africa. Joint exploration by U. S. Steel Corp. and the French Government, begun in 1951 and continued through 1953, is believed to be in progress. If successfully concluded, the project not only should bring in a new large manganese mine but also would open a considerable area for general mineral exploration. Transportation must be established to the deposit, which lies 200 air miles from the coast.

In Angola, Companhia do Manganés de Angola continued exploration of its extensive holdings at Quitota and vicinity. Active since 1949, the company is at present the Colony's only manganese producer. Although its reserves are not known, the known manganese ore reserves of the entire manganese-bearing area of Angola were estimated at 4 to 5 million tons.

In Northern Rhodesia exploration and development continued on steep-dipping manganese veins 2 to 10 ft wide. The deposits, found in 1953, are about 10 miles northwest of Fort Roseberry.

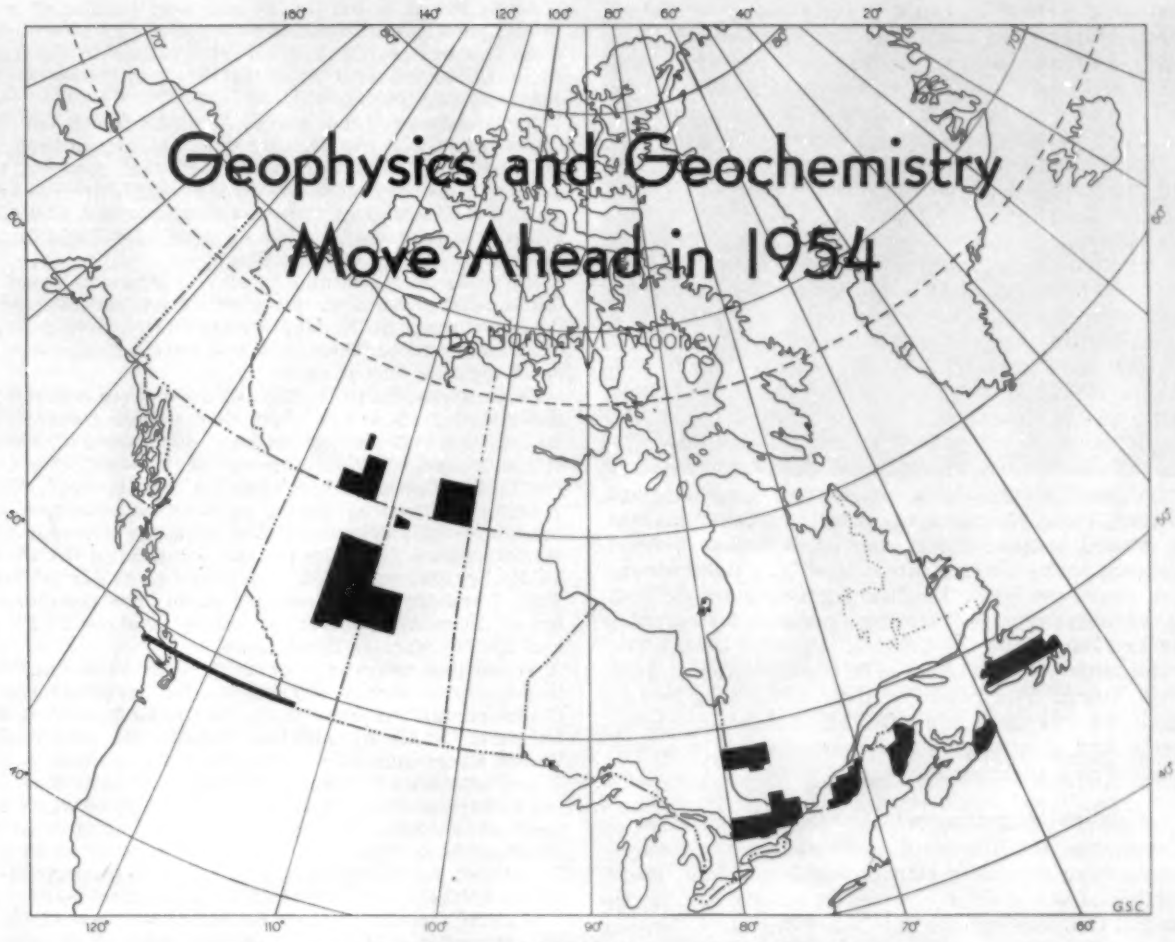
ZINC—The outstanding event in the African zinc industry for the past several years was the starting of electrolytic zinc production by Société Metallurgique du Katanga at Kolwezi, Belgian Congo, in the second half of 1953. Plant capacity reportedly is 36,000 metric tons of zinc annually. Exports totaled 12,997 metric tons in the first half of 1954.

LITHIUM—Southern Rhodesia's production of lithium ores is expanding rapidly. In the first quarter of 1954 it had reached 8780 LT. This is seven times larger than for the same quarter in 1953. The principal ore mineral is petalite, several deposits of which have been discovered in the Enterprise tin belt about 20 miles from Salisbury. A further discovery was made on the Casa Ventura farm. In this same area, on the Thorn Vlei and Lonely Park farms, promising discoveries of another lithium mineral, eucryptite, have also been made.

THORIUM—What is perhaps the richest and the most geologically unique monazite deposit yet discovered was found prior to 1950 in the Van Rhynsdorp district of Cape Province, Union of South Africa. The property has since been brought into production by Anglo American Corp. of South Africa Ltd. Expectations were that it would yield annually around 8000 short tons of concentrate containing 55 pct thorium oxide and rare earths. Reportedly all production through March 1956 has already been sold.

Geophysics and Geochemistry Move Ahead in 1954

by Harold M. Mooney



Shaded areas show extent of Canada already covered by aeromagnetic surveys.

THE most significant trends appear to be an increased use of electromagnetic and geochemical methods. The most promising instrumental developments are airborne electromagnetic equipment, a magnetometer based on nuclear resonance, and reflection seismic equipment operable to depths less than 100 ft. Work in progress may lead to a one-man magnetometer capable of high precision and continuous recording.

New Developments

Reflection seismic equipment has been developed that will give usable reflections from as little as 100 ft. For mining, this offers a new approach to shallow structure and depth of overburden problems. Houston Technical Laboratories and Bear Creek Mining Co. have run preliminary tests in Colorado, North Dakota, Minnesota, and Michigan, including a complete survey of one uranium prospect. U. S. Geological Survey equipment readily mapped limestones at 100 to 200 ft depth in Oklahoma and Kansas. Reflections from 80 ft were identified. Highly successful results were reported in mapping basement in a buried valley area in Ohio.

Varian Associates has developed a magnetometer based on nuclear induction. Polarized protons (the hydrogen nuclei in water, for example) are caused to precess in the earth's magnetic field. The frequency of precession is a measure of the field. This instrument offers hope for a high precision (1 to 2 gammas) self-calibrating magnetometer, which can be used in a light aircraft at low levels. A one-man continuous-reading magnetometer is considered possible. Two observatory instruments have been built and a more portable model is under development.

Airborne electromagnetic equipment promises speed and efficiency in sulphide exploration. Compared with aeromagnetics, the signal response drops off faster with elevation, which leads to severe requirements for low-level flying. International Nickel Co. continues to use an airborne instrument, now three years old, as a primary reconnaissance tool. McPhar Geophysics Ltd. used this equipment in locating a major base metal district at Little River, New Brunswick. Aeromagnetic Surveys Ltd. has test-flown a two-frequency instrument based on a Finnish patent. Satisfactory results were reported. A 1953 model continues to be used in Finland. Lundberg Explorations Ltd. reports use of a ground cable transmitter 5 to 10 miles long with an airborne detector flown across it at intervals. At least three other instruments are under development.

Gulf Research & Development Co. has test-flown a magnetic gradiometer that measures rate of change of magnetic intensity with horizontal position. The chief application lies in detecting small anomalies in regions of rapid magnetic change, such as contact zones.

Jarrell-Ash Co. offers a truck-mounted spectrographic laboratory for geochemistry, and a fluorimeter for accurate analysis of low uranium concen-

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trations. A new Askania gravity meter combines high accuracy and range. At Imperial College, London, electromechanical seismic sources are being tried for closer control of the signal, and will be applied to coal field structures. Prakla (Germany) is using the same method in potash mines. At Washington University, portable equipment has been constructed for telluric, or large-scale natural current prospecting. McPhar Geophysics Ltd. built a one-man flux-gate magnetometer giving moderate accuracy and requiring minimum orientation.

A recent trend in airborne geophysics is toward recording several quantities along a single flight line. Scintillation and magnetic measurements have become a routine combination, along with photography for position plotting. In the near future, airborne electromagnetics, radar altimetry, and the magnetic gradiometer may be added. Simultaneous use of all of these has not yet been reported and may await further tests on Howard Hughes giant aircraft Mars. Another trend in mountainous areas is toward contour flying, that is, flying at a fixed distance above terrain rather than at a fixed elevation above sea level. Because such data are difficult to contour, they are sometimes presented as profiles stacked one above the other, along with a magnetic trend map. A third trend is in the direction of low-level flying. The need for this, while long recognized, has become acute with the addition of scintillation and electromagnetic measurements and will require new flight equipment.

Airborne Magnetic and Scintillometer Surveys

Airborne scintillometer and magnetic measurements have become a routine combination. A large portion of world coverage was in eastern and north central Canada, and the Colorado Plateau.

USGS aeromagnetic coverage included parts of the Mojave Desert, the Appalachian Mountains, the Boulder Batholith, and western Oregon. Basin and range structure in the Mojave Desert is being studied by gravity, magnetic, and seismic methods. The magnetics serve to outline regional structures, and it has proved possible to distinguish between those basins that contain volcanic material and those that do not. Aeromagnetic profiles across the Appalachians and the Boulder Batholith were taken to provide structural data. Sedimentary structures in western Oregon contain volcanic members that permit magnetic mapping. The magnetic coverage planned for Minnesota has been completed, although not all of the data have yet been made available.

Airborne operations, mostly scintillometer but some magnetic, continue on the Colorado Plateau. The AEC contracted for about 20,000 miles of flight line during the year, much of it rim flying by helicopter. The USGS located areas of anomalous radioactivity on the Colorado Plateau and in the sedimentary basins of Wyoming. Phosphate deposits in Florida could be traced radiometrically, since these rocks contain excess quantities of radioactive material.

Aero Service Corp. published an aeromagnetic profile from Portland, Ore., to Albuquerque, N. M. Generalized correlations could be made with geology.

In Canada, about 45,000 line miles were flown by the Geological Survey of Canada. Most of the work was done in the Northwest Territories, northwest of Lake Athabaska, between the 102nd and 106th meridians and the 60th and 62nd parallels. Lines were spaced at ½ mile, flight elevation was 1000 ft above terrain. Discoveries included one magnetic anomaly with relief of 7000 gammas and areal coverages of 3 sq miles. Airborne scintillometer data on these flights showed several anomalies; however, due to the flight altitude, they were interpreted as broad areas of granite outcrop.

Along the U. S. border, 12 east-west profiles at one-mile intervals were flown across the Rocky Mountains, from Lethbridge, Alt., to the Pacific Ocean. These data, to be published at 4 miles to the inch, have chiefly reconnaissance value.

Aeromagnetic work proved a major factor in the important Cu-Zn-Ag discovery at Manitouwadge in northwestern Ontario. Fifty operators grouped together to sponsor an aerial survey. Elsewhere in Ontario, the Mines Dept. directed magnetic and scintillometer coverage of about 500 sq miles near Blind River on the north shore of Lake Huron.

Aeromagnetics continue to play an important part in Quebec-Labrador iron exploration. A recent report describes work in the Ungava region, where a pattern of broad magnetic anomalies was interpreted as due to flat-lying iron formation.

In northern Manitoba, 1000 sq miles were covered in the Sherridon area. In Nova Scotia, base metal finds during the last two years have stimulated airborne magnetic and scintillometer coverage; about 70 pct of the 21,000 sq miles of land area has been covered. This is being followed by ground exploration of anomalous areas. In Saskatchewan, 1954 coverage includes the blocks defined by latitudes and longitudes: 55°15′ to 55°45′ by 104° to 105°30′ and 56°15′ to 57° by 107° to 108°. Uranium was discovered during the summer on one of the scintillometer anomalies at about 55°35′ N and 104°50′ W, near Otter Lake.

Airborne geophysics appears to be a major exploration tool in Australia, particularly for uranium. Three combined surveys were completed during 1954: a detail survey of 900 sq miles near Broken Hill, New South Wales; a reconnaisance survey of 22,000 sq miles in the Wyndham-Halls Creek area, West Australia; and detail and reconnaissance coverage of 5000 sq miles southwest of Darwin. In South Australia, scintillometer measurements were taken over 3370 sq miles on Eyre's Peninsula, Adelaide Hills, and west of Radium Hill. Flight level for the latter two was 50 ft.

Mineral Search of Africa Ltd. took magnetic and scintillometer data over 12,000 sq miles in Northern Rhodesia, 2500 sq miles in South West Africa, and 9600 linear miles in the Union of South Africa. Some work was reported from Liberia.

Magnetic Ground Surveys

Iron exploration in the Lake Superor district depends heavily on magnetics, particularly in drift-covered areas. To some extent the magnetometer has displaced the dip needle and the superdip. Near Draper, Utah, ground investigation of an aeromagnetic anomaly may indicate possible mineralization around an igneous stock. In Woodson County, Kan., the Kansas Geological Survey located granite and peridotite intrusives by magnetics. The intrusives appeared as magnetic lows, displaced northwest from structural highs.

The Industrial Development Corp. reports a Jamaican discovery of high grade iron ore exceeding 1 million tons. Magnetic field work played an important part in this, although interpretation was handicapped by rough topography and remanent magnetization.

Near Seldovia on the Kenai Peninsula, the Alaska Dept. of Mines found that steeply dipping bands of chromite ore in dunite could be traced magnetically, provided the bands were more than 2 ft wide. As a generalization, magnetics appear to be about 50 pct successful in placer location in Alaska.

Several special applications were reported from Europe. The Minerals Ministry of Spain tried unsuccessfully to locate nickel-chromium ore in peridotite. In Hesse, the German Geological Survey located magnetic iron ores in slates intermixed with diabase. Near Vogelsberg, weathered iron ores could be detected in troughs of Tertiary basalts. A major magnetic anomaly, 100 km wide, was traced for some distance from Lausanne by personnel from the University of Geneva.

Magnetics were applied to the search for manganese ores in India. North of the Wallaroo Mines area, South

Australia, intense anomalies to 20,000 gammas may be related to old copper lodes.

In summary, ground magnetics remain a basic tool of exploration geophysics. The available data do not indicate any major trends.

Magnetics—Theoretical and Laboratory Studies

The most promising developments of the year for magnetic interpretation appear to be model studies extending GSA Memoir 47, and an intensive correlation of Minnesota geology and aeromagnetics.

An important contribution to the interpretation of aeromagnetic data, Memoir 47 of the Geological Society of America, appeared in 1951. Determinations of depth to basement rock can be made by the methods described there and the USGS applied this during 1954 in the Sudbury Basin, where the depths are known. Results appeared to be accurate within 10 pct. Similar computations are in progress for the entire state of Indiana, in an attempt to compile a topographic map for the basement.

The USGS is attempting to extend the results of Memoir 47 by model studies. Magnetite disseminated in a matrix is formed into thin slabs of constant thickness. From these, complicated structures can be built up. The method was applied to the Great Sitkin volcano, Alaska, and to several laccoliths in Montana.

An intensive study of Minnesota aeromagnetic data was started during the year by the USGS and the Minnesota Geological Survey. It is proposed to compile extensive data on rock susceptibilities, delineate geologic trends, and correlate magnetics with geology in detail.

A collection of papers on magnetic susceptibility of rocks appeared as Vol. 1, *Proceedings of the Geophysical Society of Tulsa*. A textbook on theory and operation of vertical magnetometers was published by J. M. Bruckshaw. At the University of Sydney, 50 rock samples have been analyzed in an attempt to correlate magnetic and mineralogical properties. The Geological Survey of India is working on theoretical magnetic curves for various conditions.

Gravity—Regional Studies

Regional gravity surveys continued to delineate major geologic structures with work completed or in progress in the Mojave Desert, Owens Valley, Salt Lake Valley, Greenland, Pennsylvania, Upper Michigan, Missouri, Mexico City, Paris Basin, Geneva, Anatolia, and South Australia.

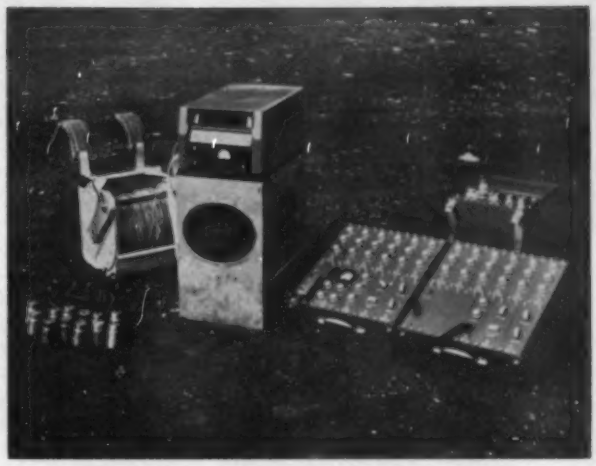
The USGS ran a regional survey on the Colorado Plateau to provide background information on the geology of uranium occurrences. In the Mojave Desert, large density contrasts exist between Tertiary basin fill and the basement rocks; gravity anomalies up to 15 mg clearly outlined structural trends. Similar results were obtained in Owens Valley and Salt Lake Valley.

Gravity work in Greenland gave information on rock topography beneath the ice cap. Gravity anomalies in central Pennsylvania were interpreted to show intrusion or upthrust of the basement rocks east of the Allegheny Front.

A major zone of positive gravity anomalies trends southwest across Minnesota from Lake Superior. Possible geologic implications are being studied at the University of Wisconsin. Michigan College of Mining & Technology extended these gravity observations by completion of a regional survey of the Upper Peninsula of Michigan.

North of the Transverse Ranges, in Southern California, the California Institute of Technology is using gravity, magnetic, and resistivity measurements for shallow structure studies. In east-central Missouri, St. Louis University took gravity and magnetic measurements over 500 sq miles, to interpret irregularities in the course of the Missouri River.

In France, the Ministry of Industry and Commerce conducted a gravity survey of the Paris basin, using 5-km station spacing. The extension of a syncline, relating to coal structures, was followed in southern Spain. The Mining Research and Exploration Institute of Turkey is doing reconnaissance work in central Anatolia, for structure.



High-resolution seismic reflection equipment developed by Houston Technical Laboratories for depth-of-overburden and shallow structure studies is one of major advances in instrumentation.

In South Australia, the Dept. of Mines completed a three-year gravity program in the Murray Basin area. Measurements in the Quorn Basin were taken for water supply puposes. Some 2000 sq miles on a 1-mile grid were covered in the Sydney Basin area, using gravity and magnetics.

Gravity—Detailed Surveys

Gravity methods found further applications in base metal exploration during 1954. The results re-emphasize the conclusion that gravity data are worth little alone, but require other geophysical or geologic information. Lake Superior iron exploration offers an example of this. Gravity anomalies up to 2 mg can be associated with the Deerwood ore member on the Cuyuna Range, yet the interpretation remains ambiguous. University of Wisconsin experience on the Vermilion and Gogebic Ranges shows gravity measurements to be much more reliable than magnetics for locating iron formation: the degree of success approximates to 75 pct. W. S. Moore Co. considers the gravity meter of doubtful value for iron work, except for replacement deposits involving high grade ore. Gravity methods were also used by Cleveland-Cliffs Iron Co., Jones & Laughlin Steel Corp., and Oliver Iron Mining Div.

Observations over an exposed serpentine plug in Travis County, Texas, showed a maximum anomaly of 4 mg. This suggests that these features could be located beneath a sedimentary cover.

No data are available on gravity work in Canada, although surveys were made. USGS reports high precision gravity results in connection with chrome exploration in the Camaguey district of Cuba. Ninety pct of the closure errors were less than 0.04 mg, which permitted use of 0.05 mg contour intervals.

The University of Leeds occupied 700 gravity stations over 15 sq miles in the South Wales coal field. Anomalies up to 0.75 could be interpreted in terms of structure within the coal measures. Gravity was also applied to coal structures near Ranigunj, India, by the Geological Survey of India.

In Germany, gravity and magnetics served to locate weathered iron ores in troughs of Tertiary basalt. Prakla had five gravity crews operating in South

America and the Near East. Seismos did gravity work in Central Africa and in northern Greece.

Electromagnetic Methods

For ground electromagnetic work, present status and trends may be summarized as follows: 1) Two methods predominate. In the first, simple dip-angle measurements are made in the field produced by a vertical transmitting loop. In the second or loop-frame method, a fixed separation of the order of 100 ft is maintained between two small horizontal loops, each carried by one man. 2) If a trend exists, it is toward measuring the simpler quantities such as dip-angle. 3) Interpretation procedures rely heavily on model studies. 4) Increasing use is made of multiple-frequency equipment, to permit discrimination among degrees of conductivity. 5) Electromagnetic methods are most widely used in Canada and Sweden with use increasing in 1954 especially in Canada.

The Geological Survey of Sweden uses electromagnetic methods almost to the exclusion of other geophysics. The loop-frame method predominates, although some work was done with magnetic field measurements around a 6 km cable grounded at both ends. About 100 sq km were covered during the year. Most of the anomalies originated in graphitic schists. The Geological Survey of Finland uses a loop-frame method with modifications of the measuring circuits.

Considerable electromagnetic work was done in eastern Canada during 1954 in the search for sulphide ores. Graphitic schists caused so many extraneous anomalies in some areas that one report questioned the usefulness of the method. Most of the exploration was done with a vertical transmitting loop and dip-angle measurements. Two large orebodies and one smaller one were found in the Bathurst area. The Coronation Mine in the Amisk Lake area of Saskatchewan was discovered entirely by electromagnetics.

In the U. S., the use of electromagnetic methods was reported by Bear Creek Mining Co., Cleveland-Cliffs Iron Co., University of Wisconsin, New Jersey Zinc Co., American Smelting & Refining Co., and United Geophysical Co. The first three used the vertical coil method. The Cleveland-Cliffs work was one of the first applications to iron mining; no conclusions are available as to its usefulness. The University of Wisconsin used the method in a search for sulphides along the boundaries of the lavas in northern Wisconsin, and for iron formation, where it worked very well.

At the 1954 AIME Annual Meeting, personnel of the United Geophysical Co. described a well-integrated discovery program which led to a major ore find in Pima County, Ariz. The clearest indications of ore were found with magnetics and electromagnetics.

Applications to sulphides were made in France and South Australia. In the search for lead-zinc, copper, and copper-nickel ores in Queensland and Tasmania, electromagnetic and self-potential methods gave results superior to most of the other geophysical methods. Loop-frame equipment was used. Electromagnetics proved useful in uranium exploration in cases where the ore was associated with sulphides. The method gave more information than radiometric measurements, due to its greater depth penetration. Clear indications were found over known deposits near Rum Jungle.

A. Belluigi mentions that electromagnetic methods are widely used in the Soviet Union.

Considerable use was made in Canada of a vehicle-borne unit, developed by H. O. Siegel for Mineral Research of Africa Ltd. Model studies are in progress or completed at University of California at Los Angeles, University of Western Ontario, McPhar Geophysics Ltd., and New Jersey Zinc Co. Magnolia Petroleum Co. described field results on an elaborate model arrangement, in which the modeling is done directly in the field. The technique at present appears too slow and limited in scope for mining applications.

Electrical Resistivity—Applications

The use of resistivity methods may have shown a moderate increase during 1954. Nearly all applications fell within three general categories: location of sand and gravel for aquifers or road fill; determination of depth to bedrock in mining, water supply, and civil engineering problems; and the direct location of certain mineral deposits, particularly sulphides. Novel uses during 1954 include underground work in a coal mine in Germany, extension of sulphur deposits in shale formations in Sicily, and archaeological exploration in Italy.

Sand and gravel lenses in clay can be readily located by resistivity. For this purpose, and for the general classification of near-surface materials, the U. S. Bureau of Public Roads reports that the method was used in 35 states and in Brazil, Great Britain, Canada, France, India, Mexico, Russia, South Africa, Southern Rhodesia, Sweden, Germany, and Turkey. In 20 states the work was done by some state agency; six of these started during 1954. Illinois Geological Survey completed 65 separate surveys to locate water-bearing sand and gravel during the year. The University of Wisconsin found the method very uniformly successful for locating sand lenses. R. P. Jacobson described a case history of gravel location in Missouri. (See MINING ENGINEERING, February 1955.)

Varying degrees of success were reported in determining depth to bedrock by resistivity. R. W. Moore reports continued satisfaction with his interpretation method, in work for the Bureau of Public Roads. H. L.

ABOVE: Another new development, the nuclear resonance magnetometer built by Varian Associates, Palo Alto, Calif. Note man in background.
RIGHT: Closeup of counting and recording equipment for the Varian magnetometer.

Scharon used resistivity measurements with success for depth determinations on the northeastern extension of the Pennsylvania Turnpike. The University of Wisconsin reports variable success; in most cases, resistivity results agreed very well with seismic refraction data, but in one or two areas they were off by a factor of from two to five.

At the annual meeting of the Society of Exploration Geophysicists, H. C. Spicer described depth determinations for water supply problems near Marshfield, Wis., and Columbus, Ohio. Using curve matching methods of interpretation, he reports accuracy of better than 10 pct to depths less than 1000 ft, and an average accuracy of 5 pct to less than 200 ft. The Kansas Geological Survey used empirical interpretation at 33 test locations in the Kansas River Valley, with an accuracy of about 15 pct in work applied to ground-water studies.

Other applications to depth determination were reported from Western Ontario, England, Scotland, Germany, Italy, Spain, Turkey, India, Malaya, Gold Coast, Nigeria, and Antigua. In England and Scotland the problem was to locate buried stream channels related to coal structures. The Turkish work applied to hematite and to lignite deposits. Most of the rest were directed toward water supply problems.

Relatively little work has been reported on direct location of minerals by resistivity methods. The Minerals Ministry of Spain tried unsuccessfully to delineate a horizontal manganese orebody; however, it apparently coincided with the water table. In Jamaica lead-zinc sulphides gave poor results due to inadequate electrical contrast and rough topography. Clay, gravel, gypsum, and limestone were located in Germany. The United Nations Technical Assistance Administration sponsored a six months' field trial of electrical, magnetic, and seismic methods in Malaya. These were used for contact zones related to cassiterite, iron ores, and damsite studies. Results are not yet available. Resistivity methods were used to locate bands of graphite gneiss in Nyasaland and manganiferous orebodies in the Gold Coast.

Electrical Methods—Theoretical and Laboratory Work

The USGS set up a physical properties laboratory in Denver. The first work will be directed toward rock resistivities and dielectric constants. Similar data were taken at Pennsylvania State University, on 18 minerals and 16 rock types. Over the frequency range 50 cps to 30 mcps, dielectric constant decreases with frequency in a regular way. This conclusion was confirmed by measurements on soils at the Defense Research Laboratory, Ottawa.

Four groups contributed theoretical results which may help in the interpretation of electrical resistivity data. As part of a larger study, K. L. Cook and R. G. Van Nostrand computed resistivity profiles over near-hemispherical depressions. These have application to filled sinks in the Tri-State lead-zinc district. The Norwegian Institute of Technology published computed resistivity profiles across assorted vertical discontinuities. L. S. Palmer computed the effects of spherical cavities in connection with field results over caves. For horizontal discontinuities, a library of 3000 two, three, and four-layer curves is in preparation at the University of Minnesota.

Seismic Methods

In mineral exploration, refraction seismology is used almost exclusively for determining depth to bedrock. Some work was tried underground in 1954 and equipment more appropriate to the mineral industries is under construction. The seismic data can be useful in water supply, mine stripping, road construction, foundation and damsite work, geologic structure studies, and as a guide in the interpretation of gravity and magnetic data. With three exceptions, work during 1954 consisted of routine applications to problems in these categories.

One exception was an attempt to apply the method underground to direct ore location. Seismos (Germany) set up a research program for this purpose. Some work was done in Siegerland. Prakla (Germany) made tests in potash mines, using an electromagnetic source for the waves.

The Illinois Geological Surveys published results of seismic tests designed to differentiate materials within glacial drift.

Various attempts were undertaken to improve equipment through reduction in size and cost, or through closer control of the signal source. The transmission of 500 to 1000-cps sound waves is under study at the University of Utah. Work at Pennsylvania State University aims to evaluate the effectiveness of a falling weight as a source. At Imperial College, London, waves from an electromechanical source are being studied as a function of frequency.

Several groups used refraction methods in the Lake Superior district during 1954. On the Michigan iron ranges, the University of Wisconsin reports that about 75 pct of the seismic results were proved essentially correct by drilling. A perched water table in the till resulted in a velocity reversal. The method was used in connection with iron exploration by Jones & Laughlin Steel Corp. and Cleveland-Cliffs Iron Co. Results were apparently satisfactory.

The USGS applied seismic methods to a ground water study in Ohio with excellent success. On the Colorado Plateau, Shinarump-filled channels in the Moenkopi formations could be located. Further work of this sort was described by D. Wantland. In an evaluation of the application to uranium exploration, R. S. Foote questions whether the results justify the cost.

Five state highway departments used refraction methods during 1954. Other applications were reported from Germany, Spain, Italy, Turkey, and India.

Miscellaneous Methods

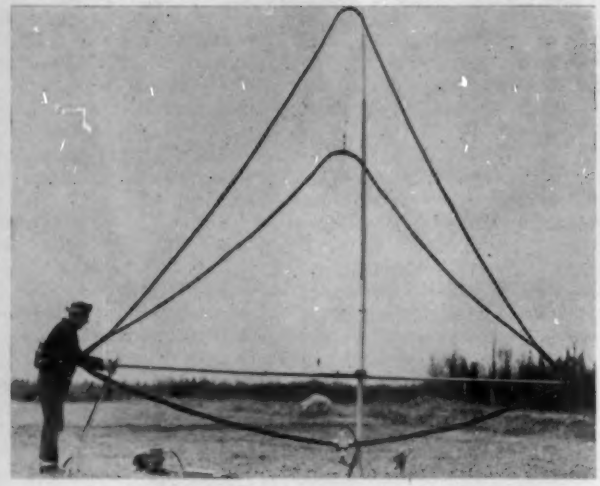
Induced polarization received much attention during the year, most of which was not publicized. Basic studies of the mechanism were made at New Mexico Institute of Mining and Technology and at Massachusetts Institute of Technology. At New Mexico, mixtures of moist clay and sand showed strong induced polarization effects. The time constant of the decay was found to be of the order of 10 sec, varying inversely with salinity of the water. Studies on aquifers are in progress.

The USGS is applying the induced polarization method to uranium ores. Some work was done by Newmont Mining Corp. and American Smelting & Refining Co. In Southern Rhodesia, Sebungwe Mines & Exploration Ltd. used the method in its investigation of the Copper King and Copper Queen mines.

No specific reports were received of **radio frequency exploration** during 1954. The detailed investigation of commercial broadcast station signals by the Illinois Geological Survey is inactive. A similar program by the Missouri Geological Survey has been under way for two years, with preliminary results indicating possibilities for fault detection.

Self-potential work was done in Canada, Italy, Germany (for graphite), Turkey, and India. **Thermal** measurements proved useful in a search for volcanic waters and natural steam in Italy, and in detecting rising water in a karst region in central Europe. New equipment was developed at University of Western Ontario and the Dominion Physical Laboratory, New Zealand.

Radiometric logging has become routine practice in uranium exploration. For coal drilling in France, the low radioactivity of the coal permitted easy differentiation from surrounding rocks. Potash zones were found to be easily separable from surrounding salt in eastern France, due to relatively high gamma activity of potassium. Experiments in the U. S. suggest that it may be possible to estimate potash content of the beds from gamma logs, and perhaps to identify the potash-containing minerals by neutron logs.



Electromagnetic induction equipment for iron ore prospecting has been developed by Cleveland-Cliffs Iron Co. and McPhar Geophysics Ltd. Close-up shows geologist using electromagnetic receiver and carrying radio gear. View at left shows the transmitting coil in use with portable generator.

Drillhole electromagnetics were described at the 1954 AIME Annual Meeting by S. H. Ward. Massive sulphide mineralization can be detected up to a few hundred feet from the drillhole; depth and direction from the hole can be specified.

The AEC set up an extensive geophysics program. To date, these methods have been used: resistivity, refraction seismic, airborne radiometric, aeromagnetic, and most of all various logging techniques.

Compagnie Générale de Geophysique, Paris, reports 54 crew-months during the year on mineral exploration (ore, coal, potash, steam).

Acknowledgments

This review was made possible by the generous cooperation of more than 100 individuals and companies.

Geochemistry Review

Geochemistry expanded rapidly during 1954, particularly in applications to mineral exploration. As evidence for growth, nearly as many papers on geochemical prospecting appeared in the last 30 months as in all time preceding. New research groups were organized. The U. S. Geological Survey set up a Geochemical Exploration Section in Denver, with facilities for training non-Survey personnel. A Geochemical Prospecting Research Center was established at Imperial College, London. The South Australia Dept. of Mines plans to add a geochemical section within the year.

The USGS continues fundamental studies on migration and concentration of minerals. To date, trace analytical methods have been developed for P, S, Ti, V, Mn, Fe, Ni, Co, Cu, Zn, Ge, Ag, Sb, Nb, Mo, W, As, and Pb. Three field reports will be published in the near future: studies in the Nyeba lead-zinc district, Nigeria; a *fossil* Paleozoic anomaly near Jerome, Ariz., and a study of the relationship of zinc-bearing peats to dolomites near Orleans, N. Y. A handbook of indicator plants for botanical prospecting will appear soon, and an article devoted to uranium was published in MINING ENGINEERING, February 1954.

The Geological Survey of Canada studied the origin of the silica in quartz veins in greenstone rocks. The silica appeared to come from the greenstone within the shear zone. Prospecting studies in a permafrost area led to the conclusion that such areas can be worked. The work was done during that part of the year when the permafrost had thawed enough to give the surface waters access to the mineralized zones.

Trace element techniques were applied at California Institute of Technology for studying the distribution of Pb, U, and Th. A method for separating oxygen isotopes from silicates promises better understanding of the origin of oxide and silicate minerals.

Direct geochemical prospecting relies on soil, water, and plant analysis, in that order of present importance. The 1954 pattern seems to consist of a great deal of isolated activity, much of it experimental and most of it unpublicized. The techniques rely on USGS developments, particularly the dithizone test for heavy ions. Portable commercial kits were made available.

In Stevens County, Wash., soil analysis for zinc led to discovery of zinc mineralization in dolomite. The zinc traces were concentrated in the upper foot of the glacial till, even though the till reached 12 ft in thickness. The Illinois Geological Survey published geochemical results on the lead-zinc area of northwest Illinois.

In Canada, considerable prospecting activity is under way in the eastern Maritime provinces. At least eight companies used geochemistry during the 1954 field season, apparently with considerable success. Soil testing was credited with a large zinc find on Cape Breton Island in an area first localized by aeromagnetics. The Quebec Dept. of Mines reports good results from water and soil sampling in Lemieux Township, Gaspé Peninsula, in an area of known mineralization, unglaciated terrain, and moderate relief. At Cobalt, Ont., analyses were made on samples at 100-ft horizontal and 1-ft vertical intervals. Increasing concentration with depth proved to be indicative of ore. Decreasing concentration was attributed to topographic and other effects.

In Queensland, Australia, colorimetric methods were successfully used on soil tests for Cu, Pb, and Zn at Mount Isa. The Australian Bureau of Mines fitted out a mobile geochemical laboratory. Botanical work was started.

The Geological Survey of Finland used a new technique for concentrating soil samples. The Bureau of Geologic, Geophysical, and Mineral Research in Paris applied geochemistry to lead-zinc mineralization near the Central Massif with encouraging results. The Geological Survey of India reports an example of coincidence of self-potential and geochemical anomalies.

In Africa, the Nigeria Geological Survey is studying trace elements in granite intrusions related to cassiterite and columbite mineralization. The Messina Development Co. Ltd. applied geochemical methods to a nickel prospect northwest of Salisbury, Southern Rhodesia. Newmont Mining Corp. used geochemistry in Rhodesia, Mineral Search of Africa Ltd., in Rhodesia, South West Africa, and the Union of South Africa.

Geochemistry applications expanded rapidly during 1954, especially in Canada. Techniques of analysis have been somewhat standardized on the basis of USGS methods. Soil history and the genetic relation of the soil to underlying mineralization remain major interpretation problems.

Beneficiation Moves Forward

Norman Weiss and
Stanley D. Michaelson

THIS was a year of realization. Some years are for planning and development, some for designing and building, others for fulfillment. With greater hopes and plans for the future than ever before, the year 1954, nevertheless, will be remembered principally because of project completion.

Among copper mines, for example, there were Silver Bell, Copper Cities, Bisbee, Yerington, and White Pine. In iron, there were the Humboldt, Coleraine, Cerro Bolivar, and Eagle Mountain. In asbestos, Johns-Manville's new mill at Asbestos, Que. In uranium, completion of the ninth mill on the Colorado Plateau—Kerr-McGee's at Shiprock, N. M. In research, 1954 marked the completion of Kennecott's Research Center in Salt Lake City, one of the historic forward strides in the science of minerals beneficiation.

The year was fruitful in other directions as well. Investigations of a fundamental nature were on the upswing, and pilot plant projects have also increased in size and number. Progress in new reagents and equipment was greater than normal. It can already be conservatively predicted—from the technological point of view—that 1955 and 1956 will be tremendous years.

Materials Handling

The first section of the gigantic conveyor system for stockpiling and shiploading Cerro Bolivar iron ore at Puerto Ordaz was completed late in 1953. The first ship was loaded in January 1954. Designed for ultimate rates of 6000 tph to stockpile, and 12,000 tph reclaiming to two shiploaders, only one half of these tonnages will be crushed and handled until the duplicate secondary crushing, conveying, and shiploading facilities are installed.

Of particular interest in this installation are the use of the traveling rotating plow for reclaiming ore from a continuous shelf beneath the 700,000 ton stockpile; the preference for short transfer conveyors to provide a means of changing conveyor direction at 90° transfers without use of sloping chutes; the use of steel-cord belts in the reclaim system; and the employment of direct current in the reclaiming system for simultaneous speed control (rather than sequence control) of all belts. Also noteworthy is the general use of wound rotor motors with controlled voltage starting in conjunction with geared flexible couplings on the large conveyors in the crushing plant and on conveyors from crushing plant to stockpile. The traveling shiploader is designed to serve vessels of all types and sizes up to 50,000 tons and to compensate for a 40-ft variation in river level.

Conveyor belts continue to improve. Combination ducks composed of cotton and rayon or nylon, or nylon and rayon, make tailor-made applications possible. Nylon cord breaker is being applied where loading impact is extreme.

Revival of interest in the perennial problem of material flow through bins, hoppers, and gates was evidenced by several papers on the subject. Andrew W. Jenicke's contribution "Flow of Solids in Bulk Handling Systems" referred to the property of bulk solids which governs flow as the *flow-factor*, and from this concept formulas of flow have developed which provide groundwork for quantitative design methods.

In the field of pumping there were two innovations of interest to millmen. The first is a centrifugal pump without stuffing box or packing gland. In contrast to conventional pumps, in which the common rotor-impeller shaft is sealed at the pump case with a stuffing box, the rotor plus shaft and impeller form one unit. The casing contains impeller, shaft, and rotor, the rotor being separated from the stator by a nonmagnetic diaphragm which forms part of the case. These pumps for clear, noncorrosive liquids are offered by several manufacturers in sizes up to 40,000 gpm.

The second innovation is the Wemco Torque-Flow solids pump, seen in action by thousands who attended the Mining Congress exhibits in San Francisco in September. The outstanding claim made for this pump is that it handles a high percentage of coarse solids and sudden surge loads without difficulty and with reasonably low wear and power consumption.

Crushing and Screening

In the conventional three-stage crushing plants that reduce run-of-mine ore to mill feed size the trend will accommodate the trend in grinding. It is expected that multiple-stage wet grinding will be employed in most future mills. This will remove some of the overwhelming burden crushing plants

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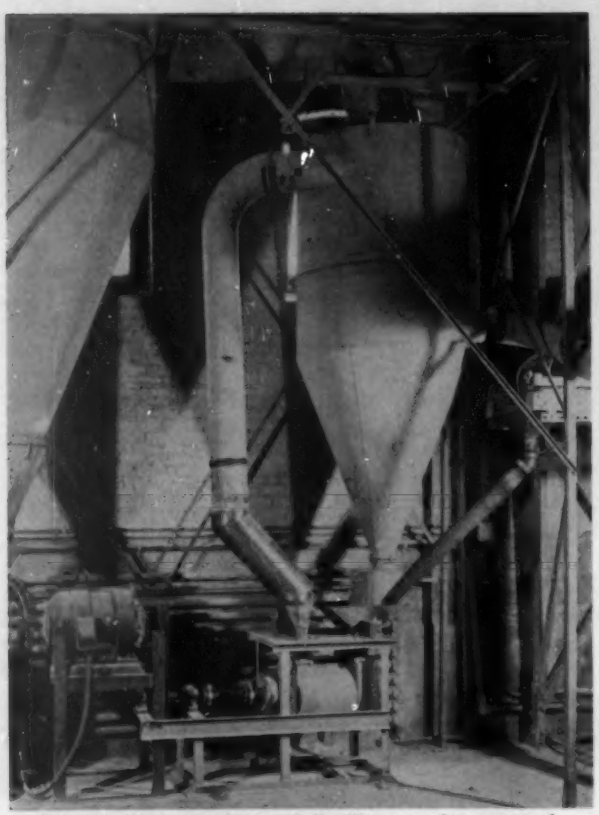
NORMAN WEISS, Regional Vice Chairman of the MBD, is Milling Engineer, American Smelting & Refining Co., Salt Lake City.



The Allis-Chalmers vibrating ball mill is something to watch. A 15x15-in. unit is shown here. First field testing was in cement industry.

had to assume when rod milling became unfashionable 25 years ago.

The majority of operators now prefer to limit rod mill feed to ¾ to ⅞ in. with 80 pct passing approximately ½ in. The trend in crushing plants, accordingly, will be to eliminate closed-circuit features, which add complexity and expense in the form of larger dust control and conveyor systems.

In the direction of controlling maximum particle size in the crushed ore by means of a fourth-stage cleanup machine, in preference to closed circuit at the third stage, the new Nordberg Gyradisc crusher is of interest. This machine, now built in only the 54-in. size, is intended to supplement the Symons cone crushers. Ideal feed is 1 in., ½ in., or ⅜-in. ore with or without fines. Alternate release and impact action from compound gyration and rotation results in a fine product. Protection is furnished by pneumatic release of the bowl from the main frame.

Which is the more efficient rock breaker, the crusher or the explosive? Fred Bond (*E. & M. J.*, January 1954) concluded that mechanical efficiencies are about equal but that crushing is cheaper. Selection of the primary crusher obviously depends upon several factors more important than the comparative size-reduction efficiencies and costs, but the significant inference is that rock crushers must be considerably more efficient than hitherto estimated.

The world's largest gyratory crusher was completed and shipped to the Mesabi for crushing taconite at the rate of 3500 tph from 60-in. max to 10-in. pieces. It will be driven by two 500 hp wound rotor motors 180° apart, which are expected to give a smoother drive than a single motor of 1000 hp.

Performance data on the much discussed Aerofall mill and experience records on furnace slags and ferrosilicon are accumulating rapidly. Installations are already completed for crushing martite in New York, asbestos ore in Canada, and gold ores in Africa (South Africa and Orange Free State). Pilot plant tests are under way or completed on uranium ores in Colorado, iron ore at Pilotac, and copper-nickel and dolomite-gypsum ores in Canada. Cost comparisons with conventional crushing and grinding are not yet available because the opportunity for direct comparison exists only infrequently. However, it seems evident that the cost factor will not be a deterrent wherever there are mechanical and metallurgical advantages in grinding dry to process fineness with little contamination by iron.

Grinding and Classification

Run into a group of millmen at a professional society meeting, and chances are they're talking about grinding and classification. Take 8¢ to 30¢ per ton for grinding and liner steel and another 5¢ to 15¢ per ton for power cost—not to speak of operating and maintenance labor and other supplies—and you have several reasons for this interest. Add to these the ever-increasing consideration of the relationship between grinding and classification on the one hand, and metallurgical efficiency or process performance on the other hand, and the fascination of the subject is explained.

Even these could not keep interest alive if it were not for encouraging response from the contrivers of new machinery and the exponents of new hypotheses—and of course the operators themselves, who believe that none is so well helped as he who helps himself.

Wear of grinding balls in relation to ball diameter, mill speed, and mill diameter was reviewed by R. T. Hukki. The weight of evidence favors the d^1 *rule* (wear proportional to square of ball diameter) in mills running at a speed approximately 50 pct of critical, while at higher speeds, with coarser ore and larger balls, the exponent of d would be the order of 2.2 to 2.5. Information is less extensive on the relationship between ball wear and mill diameter, the rule of $D^{2.6}$ having been based upon only sparse data. Mr. Hukki presented a fundamental equation for correlating the above parameters.

Walker and Shaw of MIT offered a machine grinding technique, as practiced in metal cutting and grinding, for evaluating the grinding characteristics of various materials from the ball-milling point of view. In MINING ENGINEERING, July 1954, R. T. Hukki offered several relationships between tumbling mill capacity, mill speed, power consumption, and mill diameter on the basis of hypothetical equations. One conclusion: "If the speed of a coarse crushing rod mill is increased from percentage-critical-speed 50 to percentage-critical-speed 80 its capacity will be doubled."

Culminating a long series of tests using a 30-in. peripheral-discharge rod mill, the first paper by Mitchell, Sollenberger, Kirkland, and Bergstrom added weight to the argument for higher rod mill speeds. While most efficient operating conditions occurred at 60 pct of critical speed when feed rate was 2000 lb per hr, product size indicated that the mill was underfed in relation to commercial operations. When this feed rate was doubled, higher speeds up to 80 pct of critical gave best results. A second paper by these authors will compare the significant relationships in a high-level overflow rod mill with those obtained in the peripheral-discharge mill.

Heat developed in ball mills is not a complete loss. In an interesting article on the influence of temperature upon grinding efficiency (*CIM Bulletin*, April 1954) L. E. Djingheuzian gives evidence to support the hypothesis that grinding efficiency increases with temperature and that part of the heat either applied externally or generated in grinding is transformed into useful work. This work reopens a field of investigation that has been neglected for some time. A. M. Gaudin's general article on "Free Radicals and Chemical Reaction by Comminution" reminded us that 1—physicochemical reactions may occur during grinding of crystalline solids by virtue of severance of an ionic bond or a covalent bond and 2—that the appraisal of comminution as a chemical operation may well lead to an important field of research.

A paper by Fred Bond on crushing and grinding calculations, presented at the annual meeting of the Canadian Institute in April 1954, is noteworthy because so much information of value to the designer of crushing plants and grinding circuits is concisely presented on six pages. The paper deals particularly with the "80 pct passing" criterion of size and the "third theory of comminution," for which Mr. Bond is widely known.

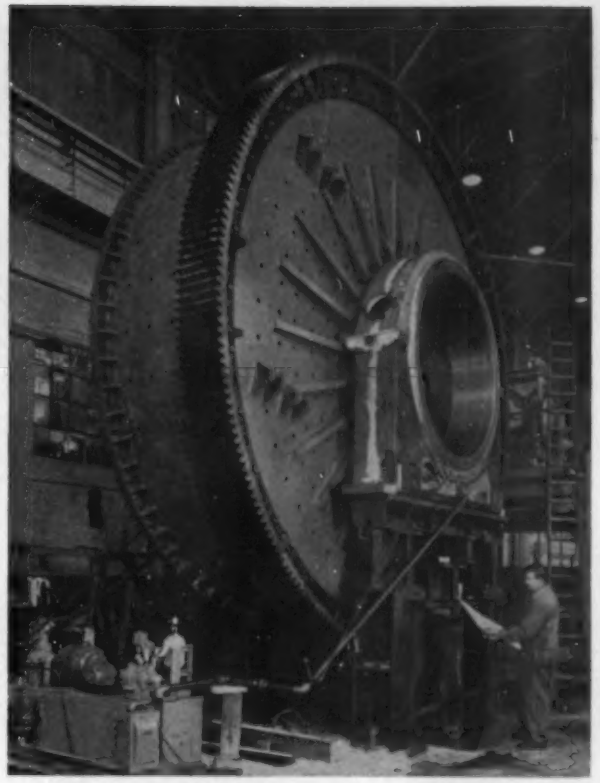
In the field of grinding practice developments should come rapidly in the next two or three years. The White Pine 12x13-ft grated ball mills, now in operation, may be expected to record some interesting grinding data next year. More will probably be heard of spiral liners, which certainly speed the passage of ore through mills and cause positive segregation of balls, the larger ones at the feed end; for some applications, to prevent excessive circulating load, only half the mill will be equipped with spiral liners, the balance with conventional liners.

Allis-Chalmers is building what is believed to be the largest ball mill ever made, 13 diam x 16 ft powered by a 1500 hp motor. It will be used for cement grinding at the rate of 200 bbl of cement per hr and will have spiral liners.

The projected installation in Canada of two 11-3x6-10 Hardinge Tricone ball mills for grinding ¾-in. uranium ore to classifier overflow of 65 pct through 200-mesh will be watched with interest, since it will be another application of the principle of ball segregation, obtained in this case by the truncated cone which forms the barrel of the mill. Four Hardinge 10x4-ft conical ball mills have now successfully completed a year's trial run at the Johnson asbestos mill near Thetford Mines, Que., dry-grinding ¾-in. rock in conjunction with air classifiers at the rate of approximately 50 tons per mill-hr. The Gyrotor air classifier is also being tested by the asbestos industry.

Operating data on the high-speed rod mill at CCI-Ford's Humboldt mill near Ishpeming will also be awaited with interest, since this new information will materially broaden the base upon which future similar installations may build. There are many experienced rod mill operators who will have to be shown that there is advantage in tumbling the rods at a mill speed 80 pct of critical.

The vibrating ball mill is still only a conversation piece to most millmen, but Allis-Chalmers considers that progress in its development is satisfactory. Several field test installations on various materials have been made for operational and design data. Performance is judged to be encouraging, and the mill will be ready soon for limited commercial use in one size.



Another new type mill coming into commercial application is the Aerofall. A 17x5-ft unit is shown here, and others are in use on asbestos fiber, gold ore, and martite.

In classification, the liquid-solid cyclone easily led the field. Here is a tool that continually finds more application and more forms of application. In grinding circuits the cyclone has already taken over the classifying function in the regrinding of concentrates and middlings and is rapidly gaining in secondary grinding (ball mill grinding following rod mills, or the second stage of wet milling). In primary classification the progress of cyclones has been unusually rapid in Africa (Rand Leases, Virginia Mine, Nchanga, Mufulira, Bancroft), where the shift from conventional rake or screw classifiers to cyclones was apparent three years ago.

In this country many of the large base-metal concentrators are testing—or planning to test—cyclones in their primary grinding circuits, but they are taking one step at a time. The cyclones are expected to supplement the conventional classifiers, not replace them. One of the principal deterrents to the exclusive use of cyclones in primary classification is the pump that must be used to feed the cyclone—such a pump must operate steadily and economically. Another is the objection by operators that they cannot judge circulating load. In Africa the closing of the classifier-mill circuit has been customarily accomplished with pumps rather than with sand wheels, spiral conveyors, or long-radius scoops, so the evolution from conventional classifiers to cyclones came more naturally and more rapidly in African mills than in ours.

Essentials of cyclone design and operation were covered in a number of papers this year, including "The Current Status of Cyclones" by A. J. Fischer, "New Cyclone Design" by Kellogg Krebs, "The Liquid-Solid Cyclones as a Classifier in Closed-Circuit Grinding of Concentrates" by F. M. Lewis and E. C. Johnson, and "Will Cyclones Replace Mechanical Classifiers?" by M. J. Dennehy.

ASARCO's 7500-ton concentrator which went into production in 1954 near Tucson, Ariz., was one of host of project completions marking the year.

When clay or similar material causes erratic classification in conventional machines the cyclone has on occasions provided a satisfactory solution. In the flotation plant of Manganese Inc. at Henderson, Nev., the presence of bentonite made mechanical classification impossible, even when the classifiers were lowered to a point where weir and sand discharge were at the same level and pulp overflow ran 12 pct solids. Cyclones in closed circuit with the mills and spiral classifiers remedied this difficult situation.

It is inevitable that the cyclone will gain ground over the conventional classifier because of many obvious advantages—sharp separations, economy in building size, short retention period, quick response to adjustments, and the generally favorable shearing action on flocs.

Other new classifiers are the Dorr Hydrovibrator or vibrating classifier and the Denver-Finney belt classifier. The former, a simplified version of the hydroscillator, probably will be tested at one of the southwestern copper concentrators early in 1955. A source of hydraulic water is used to form a hindered-settling bed which, being interposed between the overflow and rake over the whole classifier area, separates the two products with relatively sharp discrimination and keeps them separate. The essential function is performed by the hydraulic pipe system and the vibratory motion of the bottom plate. Beneficial effects upon metallurgical efficiency are expected from the improved classification. A considerable saving in floor space will be one of the main advantages of the hydrovibrator over conventional mechanical classifiers. It is much too early to guess how this development will affect the present trend towards cyclones.

The Denver-Finney classifier, which was seen in action at the American Mining Congress exhibit at San Francisco, applies a conveyor belt in place of rakes or spirals in removing sands from a settling pool retained within the belt.

In the field of ultrasonics S. C. Sun and D. R. Mitchell of Penn State presented their paper, "Desliming and Preliminary Concentration of Ores with Ultrasonics" at the AIME 1955 Annual Meeting.

In a paper published in MINING ENGINEERING, June 1954, Oscar Johnson described various methods used in this hemisphere for charging rods and balls into grinding mills. Schemes are customarily improvised at each concentrator, and Mr. Johnson's paper may help to create improved techniques.

Flotation

At the School of Mines and Metallurgy, University of Minnesota, C. S. Chang, S. R. B. Cooke, and Iwao Iwasaki investigated the flotation characteristics of pyrrhotite with xanthates. Their conclusions, published in MINING ENGINEERING, February 1954, are as follows: aeration is detrimental; activation by copper salts is beneficial, but excess cupric ion detrimental; the critical pH in pyrrhotite flotation with potassium amyl xanthate is 4.5, and acid addition greatly increases its floatability.

Flotation of oxidized zinc ores was reviewed by M. Rey, G. Sitia, P. Raffinot, and V. Formanek in MINING ENGINEERING in April 1954. Several operations in Italy, France, and French Morocco were briefly described. On the basis of six years of laboratory study and three years of mill operation treating more than 100,000 tons of ore, the authors hold that flotation of these oxidized zinc ores by combination of sodium sulphide and primary aliphatic amines is an efficient process.

The purpose of a paper by J. Leja and J. H. Schulman, University of Cambridge, was to show that surface-active agents acting as frothers become effective only when there is a suitable degree of molecular interaction between collector and frother at the water interfaces. This is one more support for the mutual-dependence hypothesis postulated, against some opposition, by Christman, Taggart, Hassialis and many other flotation observers for 20 years.

In a paper, "Flotation and the Gibbs Adsorption Equation", by P. L. de Bruyn, J. Th. Overbeek, and R. Schuhmann, Jr., the mobility of adsorbed substances on mineral-liquid and mineral-air interfaces was designated as an important factor if the Gibbs adsorption equation is to be considered compatible with actual flotation conditions. The authors concluded that further studies of adsorption at the mineral-air interface are especially desirable.

Adsorption of hexyl mercaptan was shown by A. M. Gaudin and D. L. Harris to occur on sphalerite, zincite, and willemite from water or air but was shown to be absent in the case of quartz. It appeared that the zinc minerals floated even when the adsorbed amount was less than monolayer equivalent, but the authors were not satisfied that equilibrium was attained or that the mercaptan was pure.

In the amine flotation of iron ore, Chang found that the replacement of active groups in corn starch impaired its effectiveness as a selective depressant of iron ore. Using radioassay technique and carbon-marked dodecylammonium acetate, A. M. Gaudin and J. G. Morrow have measured the adsorption of the amine from aqueous solution on hematite and showed it to be reversible. A unified theory of collector action was presented in "Some Physico-Chemical Aspects of Flotation" by C. C. DeWitt, chemical engineering dept., Michigan State College, at the AIME Annual Meeting in Chicago.

Studies at MIT on the surface chemistry of quartz through measurements by streaming potential are described by A. M. Gaudin and D. W. Furstenau, and a hypothesis for the flotation of quartz with fatty acids is postulated to conform with these data. P. L. de Bruyn has written a paper on quartz flotation by cationic collectors in which the critical pH curve for flotation of quartz with dodecylammonium acetate is established.

GREATER BUTTE PROJECT features use of Anaconda's unique Leach-Precipitation-Float process. Rougher flotation machines shown here recover both sulphide minerals and metallic copper.

Continuing the work described in his earlier paper on flotation rates and efficiency, N. Arbiter of Columbia has written, "Problems in Flotation Rate Studies," in which the engineering as well as the theoretical aspects are considered. Going further into practical aspects, W. H. Reck of Western Machinery Co. compiled and presented at Chicago a summary of handling difficult froths. The effect of impeller speed and air volume on flotation rate was discussed by W. E. Horst and T. M. Morris of Missouri School of Mines.

In summary, it might be said that flotation of the sulphides has now—and perhaps for some time to come—relinquished the stage, and the spotlight is centered upon flotation progress in other fields. Without doubt, flotation will continue to carry the burden of base metal production for many years, but fundamental research will concentrate upon oxidized ferrous and nonferrous ores, the nonmetallic ores, and other surface-active materials. For the present the tools fashioned for the beneficiation of the sulphides are being used elsewhere. The time may come when tools fashioned elsewhere may bring new techniques to sulphide flotation.

Liquid-Solid Separations

Separan 2610, developed by Dow, is the latest of the recently produced flocculating agents designed to produce clearer thickener overflows, speed up settling and filtering, and reduce cake moisture retention. Applied in hundredths of a pound per ton of solids in thickening, and in tenths of a pound in filtering, this new tool is a synthetic, water-soluble high-molecular-weight polymer, similar in application to American Cyanamid's Aerofloc reagents. Dow is also field-testing a polyglycol-fuel oil emulsion for reducing moisture content of filter cakes.

In the same connection a number of valuable reports on flocculation and viscosity effects were published in 1954 by the Institute of Rate Processes, University of Utah. Technical Report IV, *Flocculation of Mineral Suspensions with Coprecipitated Electrolytes* by Milton E. Wadsworth and Ivan B. Cutler, indicates that coprecipitation of adsorbed polyanions with polycations offers advantages in flocculation over either one alone. In Technical Report V, *Rate of Flocculation in Dilute Clay Suspensions,* the same authors, in collaboration with Theron Mackay, correlate the rate of floc growth with time and find this to be a zero order rate until critical size is approached.

In Technical Report VI, *Viscosity of Clay Suspensions in the Presence of Polyanionic Flocculants,* Mackay, Cutler, and Wadsworth investigate the effects of several reagents of this class upon the relationship of viscosity to degree of flocculation and floc size using various electrolytes. The need for careful choice of the flocculant is stressed in *Natural and Synthetic Polyelectrolytes as Flocculants for Mineral Suspensions,* by Wadsworth and Cutler, and several examples of practical application are cited.

Following the same theme R. A. Ruehrwein of Monsanto's central research dept. writes on the theory and application of polyelectrolytes to flocculation. Surface active agents—and a new tool for measuring their effect on filter cakes—are the subject also of a paper by S. C. Sun, D. R. Mitchell, and W. L. Deppe of Pennsylvania State University.

All of the foregoing serves notice that thickening,

clarification, and filtration are no longer the laissez-faire operations of the past.

Under the heading of new equipment the Eimco-Burwell filter is finding new applications. Its high washing efficiency, rapid cycle, and low requirement for hand labor are the reasons for the growing popularity of this radical improvement upon the old filter press. Typical installations are for the chemical treatment of low grade tungsten concentrates, recovery of selenium from refinery sludge, and recovery of uranium precipitate. The new dumping-pan filter is another noteworthy innovation, being applicable on coarse, free settling materials where efficient washing is required, such as the separation of phosphoric acid from gypsum. Corrugated steel sectors for disk filters are proving successful in flotation concentrate service. During formation the cake assumes a corrugated form it attempts to retain when the cloth is being inflated; lateral movement of the cake with respect to the cloth causes the cake drop. In some cases the scraper is eliminated entirely.

A new magnetic filtering device was described by Bengt G. Fagerberg of Malmberget, Sweden (*E. & M. J.*, October 1954). Installation of a magnet within an ordinary filter drum gave much improved results.

Solution and Precipitation

A year ago the reviewer noted that the line between minerals beneficiation and extractive metallurgy was growing faint. This year it can be reported that the line has not only disappeared but has also been replaced by an overlap. Copper and uranium have done the trick, and cobalt, nickel, and tungsten are close behind.

In the beneficiation of copper ores the leach-precipitation-float technique has created renewed interest by virtue of pilot plant testing now in progress at Kennecott's new research center in Salt Lake City. This process—not new, but brought to its present stature by Anaconda's success—will continue to find new applications.

The February 1954 joint session of the Minerals Beneficiation and Extractive Metallurgy divisions included papers on electrolytic production of leaching agents for manganese ores; the ammonia leaching process for nickel, cobalt, and copper sulphide ores; data on ion exchange in the metallurgical industry; and the use of jigs in Australia for continuous ion exchange. This year, in Chicago, papers described precipitation of metals by hydrogen reduction, separation of nickel and cobalt by hydrogen reduction, and uranium extraction by alkaline leach at the Beaverlodge plant.

Agglomeration and Sintering

Fine iron concentrate, rapidly becoming an important source of iron in this country, must be agglomerated before it can be reduced in shaft furnaces, and methods for making and hardening these agglomerates or lumps include sintering, nodulizing, pelletizing, and briquetting. The choice depends upon the physical, chemical, and mineralogical qualities of the concentrate, as well as economics and furnace requirements.

This relatively new technology made good progress in 1954, in the direction of particularizing the desirable qualities of sinter and evolving procedures for obtaining them under controllable conditions. Eventually it is to be expected that blast furnace operation will be modified to accommodate the sinter, so the scope of research appears unlimited.

In their paper "Solid State Bonding in Iron Ore Pellets", MINING ENGINEERING, April 1954, S. R. B. Cooke and R. E. Brandt of the University of Minnesota concluded that bonding between magnetite cubes and between magnetite and hematite cubes at temperatures below 1000°C is governed by oxidation. "Sinter Is What You Make It" was the title of a review by E. H. Rose and D. J. Reed.

At the Annual Meeting in Chicago the Allis-Chalmers process of balling and ball-hardening of concentrates prepared from taconite ores was described by W. F. Stowasser. This is the work that was first piloted at Carrollville, Wis., and later continued on Reserve Mining's 72-in. machine at Babbitt, Minn. (see **Iron**).

Tailing Disposal

Disposal of tailings and recovery of water from these residues are highly important to many operators. The few articles on the subject in technical literature have been generally descriptive, dealing principally with methods and procedures but containing little of engineering analysis.

Recent developments include the use of the cyclone classifier for constructing tailing dams, modification of tailing viscosity by chemical means, and studies of tailing dam failures from the point of view of soil mechanics. These may be precursors to a science of tailing disposal that many mill operators believe is sorely needed.

Control

Measurement and control mark the degree to which an industry has advanced technologically. In those terms minerals beneficiation made satisfactory gains in 1954.

Canadian Exploration Co., Salmo, B. C., has been working with a recording polarograph and can now use it for lead and zinc assays on mill products.

The grade of cryolite and fluorite concentrates can be determined under restricted conditions by transparency measurements, according to Sun, Fischer, and Snow of Pennsylvania State. Transmission of light through particle sediments is determined by a monochromatic colorimeter.

Two new physical techniques of analysis—quantitative fluoroscopy and infrared absorption spectrometry—are proving extremely useful at the new Kennecott Research Center in Salt Lake City. The infrared absorption spectrometer is especially useful for organic analysis of such materials as frothers, collectors, and the raw materials from which they are made. A comparison of recorded *fingerprints* will identify complex mixtures that would be difficult to analyze by classical methods.

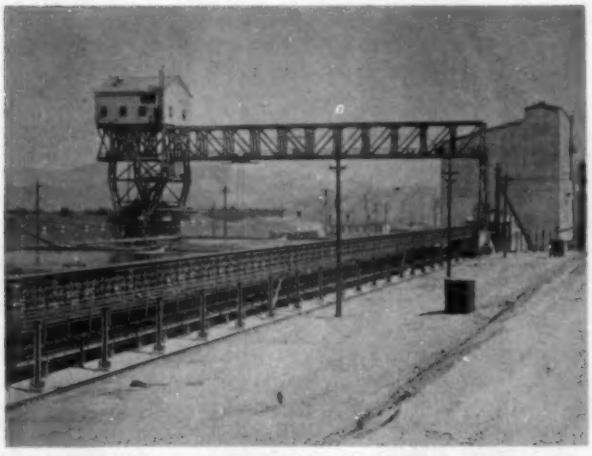
Absorption charts are now available for differentiation of clay minerals. Although this has usually been done by X-ray analysis the infrared technique is simpler. Other minerals and rocks may be identified by the infrared method, but as in the case of X-ray it applies only to a selected sample and not to random mixtures.

X-ray fluoroscopy is proving valuable for rapid quantitative analysis of ores and tailings. The procedure is different from that used in spectroscopy in that a substantial weight of material may be taken and quantitative results obtained in a comparatively high range. At Kennecott's Research Center the technique has been applied to a number of elements with atomic number 22 or higher. After the necessary calibration, triplicate readings can be made in a few minutes, and more than one element can be determined from one sample.

Yerington — The Leaching Plant

The FluoSolids plant at Yerington is shown with the contact acid plant at right.

East side of leaching tanks, with trucks loading for haul to tailings area.



General view shows leaching tanks and bridge at the Yerington copper plant.

Close-up of cementation launders shows bridge and materials handling equipment.

In round-the-clock campaigns in the Research Center's pilot plant the operation has been controlled by fluoroscopy analyses; within 5 min a shift tailing copper assay could be given to the operator. Within reasonable limits the moisture content of the sample surprisingly had no effect. This opens the way to continuous recording of mill product assays at 5-min intervals.

In the field of automatic control of unit operations progress was not outstanding. A new bin level control may be mentioned—the Robin-Tronic level indicator, made by Hewitt-Robins, which consists of a remote control unit and a small radio transmitter housed in a steel probe. Deister Concentrator Co. brought out a new pulp distributor designed to effect distribution among several connected pieces of equipment, any one of which is always held in reserve as a spare, and to provide remotely controlled electrical means for distributor control so that the desired spare may be quickly selected by pushbutton.

Alvin F. Kroll of Bunker Hill & Sullivan described (MINING ENGINEERING, June 1954) the successful application of density control and recording as used in Bunker Hill's concentrator at Kellogg, Idaho. This installation has withstood the test of one year's operation and is considered wholly satisfactory, having achieved the dual objective of constant classifier dilution and uniform particle sizing. Both of these have contributed to improved operation and higher metallurgical efficiency—possibly also to increased production.

Automation in minerals beneficiation plants is still a hit-or-miss affair, aside from one or two exceptions achieved in classifying. Its general adoption is inevitable, but progress is slow—principally because the controlled variables are more variable than controllable. There is much to be learned about the flow of bulk solids, dry and in pulp, before automation will reach the high standards set in the chemical industries.

Control of process by statistical analysis was the subject of a new paper by A. C. Dorenfeld of the University of Alabama (MINING ENGINEERING, October 1954). The object of the paper is "to stimulate both thought and action in applying available mathematical tools to analysis of complicated metallurgical data." Experimental or operating data cannot be correctly evaluated without mathematical correlation, and similar calculations may be expected in future technical reports.

RESEARCH AT WORK: Don Olsen, of the Kennecott Research center, making a quantitative grain count on pilot plant product with an integrating stage.

The dedication of Kennecott's Research Center on the campus of the University of Utah on Aug. 13, 1954, marked the beginning of an era. This is a central facility for handling expanded research programs for Kennecott's western operations. The pilot plant and laboratories are equipped to study many types of metallurgical problems and fundamental research.

Until now most research programs in the minerals beneficiation industry have been of the trouble-shooting type, carried on at each mill as the circumstances warranted. Fundamental investigations and well-integrated study programs have been left for the universities, Government bureaus, and commercial research centers such as Battelle. The Kennecott venture is a notable advance because by centralizing its research activities it can have fine equipment and well-trained specialists that could not possibly be found for each separate operation of a widespread company.

Research centers such as the Kennecott are integrated scientific and technical organizations capable not only of investigating the immediate problem, but implemented also to study the fundamentals of the process, the origin of the raw materials, and the value of the product or the process in an economic sense.

The Salt Lake Center is staffed with several physicists, physical chemists, mineralogists, a petrologist, and even a biochemist, to supplement the abilities of experienced millmen, ore-dressing investigators, and chemical and metallurgical engineers.

Analytical research is one phase of the work. Nothing is more confusing to the ore-dressing researcher than inconsistent, inaccurate, or unrationalized chemical analyses. Often the ore dresser is comparing flotation reagents, or the quality of the mill water, or the effect of a slightly finer grind of the ore or other variables which can yield only a few (but important) cents per ton of ore treated. In many cases, the analytical methods employed may not be sensitive enough to reflect these benefits. In a large-scale operation, a difference in analysis of as little as 0.002 of an oz of gold per ton of tailings means more than $1 million per year.

The new technology is requiring rare and unusual metals which occur in small quantities. These are also in demand where the classical wet methods sometimes are inadequate. Small amounts of molybdenum, tungsten, thorium, cerium, germanium, rhenium, columbium and tantalum, rare earth metals, cobalt and nickel, uranium and selenium present analytical problems. In an integrated research laboratory the chief chemist has available tools such as flame spectrometry, polarography, X-ray fluoroscopy, spectrography, infrared absorption spectrometry, ion exchange, and partition-coefficient techniques to supplement the established methods of wet and fire assaying. Under these conditions, the ore dresser can sit down with the chief chemist, find out how accurate the results are likely to be, and arrange for more accurate determinations when justified or for quicker reporting when rapid but less accurate analyses are adequate.

The pilot plant facility at the Center is indispensable for closed-circuit work. A complex beneficiation operation beginning with crushing and ending with the disposal of tailing has been conducted on a continuous basis for two campaigns with an operating-time efficiency of +99 pct. Such a plant, together with supporting scientific services of a high order, is an outstanding example for the entire industry.

The formal opening of the new laboratories and pilot plant of the Research & Development Div. of the Rhoanglo Mine Services in Northern Rhodesia is another step in the direction of coordinated, centralized research.

Trends:

Research—Chemistry—Flotation

Centralization of research and engineering is an unmistakable trend, brought about in part by the high cost and scarcity of specialists and special equipment. The shortage of engineering, technical, and scientific personnel is critical and will become more serious. Better utilization by avoidance of duplication and waste is one answer. Another is to encourage more young people to enter the field. Young women should be offered many of the technical positions now occupied by young men who—once relieved of routine tasks—could assume more responsible work. This would increase the incentive for women to study engineering.

More than anything else that happened in 1954, the national meeting of the American Institute of Chemical Engineers in Glenwood Springs, Colo., in September proved that minerals beneficiation is leaning strongly towards chemical engineering. Out of 27 papers presented, five were on oil from shale, five on the processing of uranium ores, one on general extractive metallurgy, six on agglomeration, five on chemical engineering fundamentals, and the rest on the role of chemical technology in the future. Not only did it seem that 12 of the 27 papers concerned MBD'ers more than the chemical engineers, but MBD was strongly represented in the registration.

At the February 1954 luncheon of MBD, Harry Benedict, the Richards Award recipient, warned of the danger of prophecy but ventured the thought that the revolution to end all revolutionary (milling) processes came in with flotation. For 1955 it is safe to forecast that the trend will be to broaden the existing base by extension of flotation to other fields, rather than to displace flotation by newer processes.

Developments by Commodities

URANIUM: Uranium milling is a fertile field. Existing milling capacity, even including expansions now under way, is lagging behind requirements, and because of the terrific rate of discovery, rock is piling up everywhere waiting to be milled. There are close to 500 operators producing uranium ore in the U. S. at the end of 1954, and most of the ore was produced on the Colorado Plateau. Here seven expansions at the existing eight processing mills were announced during the last eight months of 1954, and with the completion of a new mill at Shiprock, N. M., in November 1954, nine uranium mills were operating at the year's end. Negotiations for a tenth mill at Moab, Utah, were nearing the signing stage and in addition AEC has received proposals for the erection and operation of processing plants at other locations in the western states, the reviews of which will be expedited in furtherance of AEC's program to provide adequate milling facilities. All mills in this area except one are owned and operated by private industry under the terms of individual contracts negotiated with the Grand Junction Operations Office of the AEC.

Mills on the Plateau

Rifle and Uravan, Colo., are owned and operated by U. S. Vanadium Corp.; Durango and Naturita, Colo., are owned and operated by Vanadium Corp. of America. Agreements for the addition of substantial new facilities were announced for Durango in June and for Naturita in November 1954.

The Salt Lake City plant is owned and operated by Vitro Uranium Co., which in May 1954 announced a major expansion program to increase its milling capacity by 50 pct.

At Grants, N. M., Anaconda Copper Mining Co. is owner and operator. A contract with AEC in May 1954 called for enlarging the existing carbonate leaching plant and construction of a new acid leaching plant; another contract in September 1954 was signed for enlargement of the acid leaching plant during construction.

Climax Uranium Co., a subsidiary of Climax Molybdenum, is owner and operator at Grand Junction, Colo. Expansion plans were approved October 1954.

Owned and operated by Kerr-McGee Oil Industries Inc., the first plant built specifically for the processing of uranium ore was completed at Shiprock, N. M., September 1954, but several months before it started to operate increased supplies of uranium ore prompted a decision to enlarge the capacity.

At Monticello, Utah, the Galigher Co. of Salt Lake City operates under contract to the U. S. Government, owner. In May 1954 AEC awarded a contract to Galigher to provide additional plant facilities for treating large tonnages of widely varying types of uranium ores that had accumulated as a result of the Commission's willingness to buy ores other than those of the carnotite-roscoelite type.

In addition to the milling expansion program, AEC completed the construction of more pilot plant facilities for uranium ores at the Grand Junction Operations Office. Objectives of the pilot plant program, both in acid and carbonate leaching processes, are to solve with greater efficiency certain metallurgical problems related to improved recovery and also to mill refractory ores with equipment that may be scaled up for application in full-scale plant operations. AEC's Raw Materials Development Laboratory of Winchester, Mass., is operating the Grand Junction pilot plant. Another pilot plant in Grand Junction is scheduled to be built by Minerals Engineering Co. for the testing of a new intermediate step in uranium ore processing. Processes to be tested may lead to construction of many small plants near mining centers for concentration of ores, thus eliminating high cost of hauling.

There are many methods of academic and experimental interest for concentrating uranium minerals and solubilizing uranium; however, in commercial application they consist essentially of acid leaching and carbonate leaching with several possible modifications according to type of ore, silica, and lime content, and other mineral constituents or contaminations. Once the uranium extracted from the ore is put into solution and the solution separated from the leach tailings, it must be recovered again from the solution by any of several possible extraction methods which cannot be discussed at the present time for reasons of security. Though great efforts have been made on the flotation of uranium minerals, results have been unsatisfactory. The only promising application of flotation so far seems to be a preparatory step for leaching—removal of carbonaceous material from asphaltic-type uranium ores and separate leaching of the two fractions, or removal of lime from high acid-consuming ores, subsequent acid leaching of the low-lime tailings, and leaching of the high-lime concentrate in a carbonate circuit.

While the foregoing paragraphs were concerned with uranium milling on the Colorado Plateau and surrounding area, there are other uranium sources in South Dakota and uranium byproduct in the phosphate fields. International Minerals & Chemical Corp. at Bonnie Phosphate Chemical Plant near Barlow, Fla., has started its new byproduct plant to recover uranium from phosphate on a commercial scale; Virginia-Carolina Chemical Corp. has recently completed construction of a byproduct unit at its new triple superphosphate plant at Nichols, Fla.; Blockson Chemical Co., a producer of sodium phosphate chemicals in Joliet, Ill., has been in full production since 1952 obtaining uranium as a byproduct of the production of the chemicals; and Texas City Chemicals Inc., Texas City, reached full production early in 1954 recovering uranium concentrates as a byproduct of phosphates.

Canadian Plants

Canada has at present two plants for treating uranium ores, both operated by Eldorado Mining & Refining Co., one at Port Radium, the other at Beaverlodge, northern Saskatchewan. Within the next year or so, at least four more plants may begin milling uranium ores: Eldorado is already engaged in building another plant to increase the Beaverlodge output; Gunnar Mines has a 1250-ton plant under construction at its Athabaska property; Pronto Uranium Mines will build a concentrator in the 1000-ton class in the Blind River area of Northern Ontario; and Cardiff Uranium Mines is considering installation of a mill near Wilberforce, Ont., for recovery of a gravity concentrate from an ore where the mineral is uraninite occurring with carbonate and fluorite minerals.

More Mills in Africa and Australia

Elsewhere in the world, Australia is fast becoming a major producer of uranium. It has now two mills operating: at Rum Jungle in Northern Territory the first full-scale plant for treatment of uranium ore in Australia started up in September 1954, and at Radium Hill, South Australia, a uranium mill opened in October 1954. Concentrates from both mills will be refined in a new plant under construction at Port Pirie.

In Africa there will be 22 gold mines producing uranium as byproducts in Transvaal and Orange Free State by 1955. In Northern Rhodesia a pilot plant will be operated for uranium recovery from copper ores of the Mindola mine at Nkana, and the Belgian Congo now as ever is a big producer of uranium.

Rumor has it that behind the Iron Curtain in East Germany the secrecy-enshrouded uranium mines in the western part of the Erzgobirge in Saxony are worked out. New efforts are being made, however, to increase production from the adjacent mines in Czechoslovakia, and near Gera, Thuringia, discoveries of extensive shallow deposits near the surface are being investigated.

TUNGSTEN: Some new tungsten concentrators were started in 1954: a 50-ton custom mill by Toiyabe Mining & Milling Co. near Gabbs, Nev.; a 100-ton gravity mill by Trojan Mining & Milling Co. at Toy, Nev.; a 250-ton gravity and flotation plant near Pallasca, Dept. of Ancash in Peru. Mineral Engineering Co.'s mill at Glen, Mont., which began operations in November 1953, is now milling about 440 tpd. Banner Mining Co. near Sahuarita, Ariz., started a 400 tpd copper-tungsten mill in which a scheelite concentrate is recovered by gravity concentration.

Getchell Mine Inc. at Getchell, Nev., increased the milling rate on tungsten ore from 900 to 1200 tpd during the year. Approximately one third of the tonnage is custom ore. The effect of temperature on scheelite recovery was found to be important and led to the installation of a steam heating plant in order to maintain the pulp temperature in the flotation circuit at 68° to 72°F during the winter months.

CHROMIUM: The American Chrome Co. is currently mining and milling 1000 tpd of ore running 19 to 21 pct Cr_2O_3 near Nye, Mont., and producing approximately 400 tpd of 38 pct concentrate for stockpile at Monat. The process consists of grinding to about 20 mesh in rod mills, tabling, retabling of coarse table middlings, tabling of overflows from dewatering and hydraulic classifiers and middlings resulting therefrom, and dewatering of final concentrates. Close mill control, proper classification, and sizing must be exercised if concentrate specifications are to be met.

Early in the year the Rhodesia Chrome Mines Ltd. started its new Heavy-Media separation plant at the Peak mine near Selukwe in Southern Rhodesia. The Rhodesian Vanadium Corp. (subsidiary of VCA) has started a new mill in Southern Rhodesia to supply concentrate for ferrochromium and chrome-silicon alloys in the U. S.

IRON: In spite of the drastically curtailed iron ore production during the 1954 season, steady progress continued in the beneficiation field with respect to new plant facilities and flowsheet improvements. This held true in the vast taconite ventures as well as at concentrating plants of the more conventional type. Steel company officials whose firms are investing more than $500 million in development of taconite production on the Mesabi Range predict that 12 million tons of taconite per year will be shipped from Minnesota by 1958 and that an annual production of 23 million tons of taconite concentrates can be expected by 1963.

A tremendous building program is under way on the East Mesabi Range and on the north shore of Lake Superior in connection with the taconite development. Both Reserve Mining Co. and Erie Mining Co. are building large concentrators and will build separate railroads to the north shore of Lake Superior, where harbor facilities are being provided and where power plants capable of supplying the requirements of each company will be constructed. In late 1954 the two companies had some 6000 men employed on construction work and this number will be increased in 1955.

Reserve Mining Co., jointly owned by Armco Steel Corp. and Republic Steel Corp., is building the E. W. Davies Works at East Beaver Bay with an ultimate capacity of 10 million tons of high grade concentrate per year. Scheduled to go into production late in 1955, the initial plant, consisting of 12 sections, will turn out 3.75 million tons of iron ore pellets per year. A successful new process for heat hardening taconite pellets has resulted from research and test work done by the Reserve Mining Co. at the Taconite Pilot Plant at Babbitt, Minn., in conjunction with test work of a similar nature carried out by the Allis-Chalmers Mfg. Co. of Milwaukee and Arthur G. McKee & Co. of Cleveland. A traveling grate loaded with pellets moves through a long horizontal furnace; heat propagation after initial burning is down through the bed. This process has been adopted for use in the large scale plant of the E. W. Davis Works.

Erie Mining Co. had the first full-scale taconite pilot plant in operation in 1948 and is embarked on the construction of a commercial installation said to be the largest initial ore concentrating plant ever built. It is set up for a production of 7.5 million tons of pelletized concentrates per year and start of operations is scheduled for early 1957. The plant will be located northeast of Aurora, Minn. Foley Bros. Inc. has been awarded the general contract for construction. Each item of equipment, with one exception, will be of approximately the same type and size used in the existing pilot plant at Aurora. As at Reserve, Erie has adopted pelletizing as the form into which the powdered taconite concentrates are made to be acceptable for blast furnace use. However, specially designed oil-fired, shaft-type furnaces are to be used for heat-hardening the pellets. Many millmen will be interested in the fact that at both mills cyclones will be used to close the grinding circuits rather than the more conventional mechanical type of classifier.

Although no plans appear in the offing for full-scale taconite production by the **Oliver Iron Mining Div.** of U. S. Steel Corp., progress is still being made in the pilot plant operations. At Pilotac, the company's taconite pilot plant, operating refinements have been made so that a 98 pct operating time has been achieved. Some flowsheet changes are planned, one of the more striking of which calls for a three-stage grinding circuit as opposed to the two-stage grinding now used.

At the Extaca installation, where a nodulizing kiln is being used successfully to form and heat-harden taconite concentrates as well as fine material from direct shipping ores, certain additives are being used with the charge to improve operating conditions. Addition of limestone and hydrated lime increase permeability of the charge to the ignition gases, thereby reducing heating time and increasing kiln capacity.

On the Marquette Range near Ishpeming in northern Michigan, the **Cleveland-Cliffs Iron Co.,** together with the Ford Motor Co., has started operation of its Humboldt mill, treating low grade specular hematite-quartzite *jasper* ores which are similar to the taconites of Minnesota. Since the iron-bearing minerals are nonmagnetic, however, an all-flotation process is employed; thus the Humboldt mill is the first commercial iron flotation plant in the U. S. The present treatment rate is approximately 1700 LTpd and an ultimate expansion to 5000 tpd capacity is planned. Briefly the flowsheet includes grinding to −65 mesh, desliming in cyclones, partly dewatering the sands, conditioning the sands with reagents (chiefly oleic acid and Dowfroth 250) dilution to 35 pct solids, and rougher flotation with double cleaning of the concentrates. Grinding is accomplished with an open-circuit high-speed rod mill followed by ball mill in closed circuit with hydroscillator. Heads run about 34 pct Fe, concentrates over 60 pct Fe, recovery by weight is about 44 pct, and recovery of Fe over 85 pct. Construction is proceeding on a mill of similar design at the Republic mine, also for treatment of *jasper* ores. The successful operation of the Humboldt mill has spurred interest in the flotation of hematite ores. A number of research laboratories are actively investigating the flotation of washing tailings and nonmagnetic taconites. It is thought by some that flotation can be more successfully used than magnetic roasting and magnetic concentration.

On the Mesabi Range keen interest was turned to the West Hill plant of Pickands, Mather & Co., which commenced operation of its two-unit cyclone concen-

IRON ORE IN THE WEST: Eagle Mountain beneficiation plant of Kaiser Steel Corp. Primary crusher is in foreground, Heavy-Media separation plant in left center, and shipping surge piles at right center.

tration plant at the start of the season. The flowsheet embodied all the newest innovations that have come to light during cyclone concentration of fines. A near copy of the West Hill plant is under construction at the company's Tioga property and will begin operation in early 1955. Key unit of this plant will be an 8x8-ft Wemco Heavy-Media drum separator with a capacity of 230 LTph. The Tioga mine is of particular interest since it is in an area which is some 6 miles to the west and south of any existing mines on the Mesabi. Pickands, Mather is also building a new concentrator for operation to start with the 1955 season at its Bennet mine near Keewatin, Minn. This plant, which will treat 500 LTph, will consist of crushing, screening, washing, Heavy-Media, and cyclone sections, replacing an existing crushing, screening, and washing plant. Another Heavy-Media and cyclone plant was built by Pickands, Mather at the Mahnomen property on the Cuyuna Range, and the addition of a sink-float plant to the present washing and jig operations at its Danube mine is under construction for treating the coarser portion of the washed ore requiring concentration. At this property the —⅜-in. portion of the ore will continue to be treated by jigs.

The Oliver Iron Mining Div. marked 1954 with the opening of its Plummer mine and washing plant near Coleraine, Minn., a reflection of the increasing trend toward utilization of the leaner ores of the western Mesabi. The company has also started plans for a Heavy-Media and cyclone plant at its Gross Marble plant near Marble, which is expected to be operating late in the 1955 season.

At the Book mine of the North Range Mining Co. on the Menominee Range, a small Heavy-Media plant designed to handle 1000 tons of crude ore per 8-hr shift has been set up to treat substantial tonnages of a low grade ore shown by test work to be amenable to sink-float separation. This plant is unique in that it is the first time the Heavy-Media process has been applied to treat current production from an underground mine.

M. A. Hanna Co.'s washing plant of the Carlz mine at Keewatin, Minn., has added a single-unit Heavy-Media section and a three-story jig section, —1¼ +3/16-in. size to be treated in the Heavy-Media unit and —3/16-in. classifier product by the jigs. At its Morton mine M. A. Hanna has a combination crushing, screening, and washing plant in operation, designed to handle up to 1000 tons of crude ore per hr.

Use of the Heavy-Media process has become standard on the Mesabi for treating the +⅜-in. portion of ores requiring more than a washing treatment. Drum-type separators are becoming the most favored type of apparatus. There is no unanimity of opinion regarding the treatment of the —⅜-in. fraction. The larger operators seem to lean more and more to the use of the cyclone process for this operation, but many smaller operators are doing a considerable amount of work with jigs. Even though cyclones have gained in prominence during recent years for the treatment of ore fines, the use of jigs on this same size fraction has also commanded some attention of late. A mobile jig pilot plant has been tested by several companies during the past two seasons. Several full-scale jig installations have been installed and more are being contemplated. One company is also experimenting with a jig of somewhat different design for use on —48 +200 mesh material, heretofore most successfully treated by spirals or hydraulic sizers. The distinctive feature of this jig is a high frequency pulsation coupled with a short stroke.

The beneficiation plant of **Kaiser Steel Corp.'s** Eagle Mountain mine in California went into operation in May 1954 to treat iron ore for use in the Fontana blast furnaces. The plant, designed to handle 700 tph, will ultimately consist of four units, of which three are now completed.

Until about 1950 the Benson orebody in the Adirondack region of northern New York, operated by the New York Ore Div. of **Jones & Laughlin Steel Corp.**, was represented as a magnetite deposit. Actually the type of iron content varies, running from nearly all magnetic iron in some zones to nearly all nonmagnetic in others. For this reason magnetic separation and gravity concentration are applied in two separate concentrator sections. The crushing plant, common to both sections, has one feature which deserves consideration by millmen, namely a fourth crushing stage. End product is essentially —⅝-in. The magnetic concentrator, treating 130 LTph, originally utilized two stages of magnetic separation, the first operated at high intensity to produce a relatively iron-free tailing and a rough unsized concentrate which was sized at 20 mesh, the oversize going to a regrind circuit and the undersize going to a second stage operated with controlled intensity to produce a finished concentrate and

a middling which was reground and recirculated through the magnetic circuit. But magnetic separation was not sufficiently selective for the second-stage concentration and tests proved that an improved grade of concentrate could be made at a somewhat coarser size by use of jigs to separate free magnetite from the middlings in the primary separator concentrate. The martite concentrator, treating 120 LTph, applied Humphreys spirals for separation in three stages, the tailings of the first stage being sized and the fines treated on magnetic drum separators before they are discarded. Additions are now being made to the martite concentrator to double its capacity. The concentrating flowsheet will be approximately the same as that used in the existing plant; however, an Aerofall mill will be used to reduce a combination of primary and secondary crusher products to —14 mesh for concentration.

In eastern Texas, **Sheffield Steel's** new beneficiation plant of 300 tph capacity treats brown iron ore (limonite) from deposits in Cass, Cherokee, Marion, and Morris counties. After passing through a crusher and a blade mill and over vibrating screens, the ore is finally washed in three 78-in. Akins screw-type classifiers. Concentrates produced average 44.74 pct Fe.

Republic Steel Corp. and National Lead Co. have joined in a project to upgrade nonmagnetic iron ore and other iron-bearing materials. A large-scale pilot plant has been built at Republic's Spaulding iron mine near Birmingham, Ala., the iron concentrates of which are expected to be sufficiently upgraded for use in modern blast furnaces.

While iron ore production in the Lake District in 1954 had to be severely curtailed for lack of demand, foreign deposits of high grade iron ore which had been developed by U. S. companies as replacements for the declining resources in the States came into production and thus were partly responsible for the lower production in the Lake District. Orinoco Mining Co., the U. S. Steel Corp. subsidiary in Venezuela, made its first ore shipment from Cerro Bolivar to U. S. ports early in 1954. Its output is expected to reach a 5 million ton annual rate by 1955.

Iron Ore Co. of Canada started shipping iron ore from Ungava in Labrador to the new port and dock facilities at September Isles on the St. Lawrence River after completion of 357 miles of mainline railroad.

Marcona Mining Co., formed by Utah Construction Co. and Cyprus Mines Corp., has improved its ore handling facilities by installing two secondary crushers and increasing the storage capacity to 100,000 tons of shipping ore at San Juan Bay in Southern Peru.

Fenimore Iron Mines Ltd. has retained Battelle Memorial Institute, Columbus, Ohio, to estimate cost of an iron ore concentrating plant at Ungava Bay on Canada's North Atlantic coast for a 1 million-ton annual capacity. Part of Battelle's job will be to determine concentration characteristics of Fenimore's North Finger Lake ore deposit. The district contains about 200 million tons of ore, mineable by open pit and close to tidewater. Fenimore's two concessions in Ungava contain some 1 billion tons of ore.

At San Leone, an iron mine on the Isle of Sardinia, a magnetic separation plant is under construction that will be the largest of its kind in Italy. Full capacity will be from 200,000 to 300,000 tons of magnetite concentrate per year. The plant is expected to begin operations in 1955.

MANGANESE: Manganese Inc.'s plant, rebuilt after a fire in the flotation section in June 1953, resumed operation later in the year in the nodulizing section and in January 1954 in the flotation section with capacity of 1200 LTpd. Among the new plants are Colitz Mining Co.'s 1200 LTpd washing and HMS plant at Damascus, Va.; Pumpelly Mining Industry's custom mill at Wickenburg, Ariz.; Tower Milling & Mining Co.'s mill at Truth or Consequences, N. M.; and Manganese Chemicals Corp.'s new leaching system at its Riverton, Minn., plant. The Cía de Manganeso Oriental Americano, subsidiary of Pan American Minerals Corp., is planning a mill of 800 to 1200 tpd capacity to produce 250 to 400 tons of 50 pct manganese nodules.

A recent article by Charles Prasky of the USBM (*E. & M. J.*, November 1954) presented the results of roasting and leaching tests on the manganese-iron carbonate deposit of the Cuyuna range. This report culminates three years of investigation by the USBM. The process is differential high-temperature sulphatization. Although the study of leaching processes for recovery of the manganese is continuing, early results showed excellent extraction with the sulphuric acid roast process.

ASBESTOS: Processing of asbestos rock, though already a multimillion dollar industry with heavy expansions in sight, generally is not recognized as the important and fertile field of minerals beneficiation into which it has grown gradually. Total world output of asbestos in 1953 was estimated at 1.5 million tons, of which Canada alone produced better than 60 pct (911,700 tons), followed far behind by South Africa with 115,000 tons, Southern Rhodesia with 77,000 tons, and the U. S. with only 48,000 tons in fourth place. Asbestos has been made the subject of intensive study and research and thus has found constantly widening application, especially in the construction and electrical industries.

The biggest installations of asbestos mining and milling are found in Canada's Province of Quebec, where three new mills were completed or partially completed in 1954 and a fourth is in the planning stage. At Asbestos, Que., Canadian Johns-Manville Co. started the first unit of its giant new mill on Sept. 30, 1954. The new mill, occupying a 14-story steel and concrete building with 22½ acres of floor space, will reach its final capacity of better than 15,000 tpd early in 1956 and will produce about one third of the world's asbestos supply. Gradually it will supplant operations at several smaller mills which are becoming obsolete. At Normandie mine, Asbestos Corp., which now operates four mills with a total capacity of 14,000 tpd, has nearly completed a new 5000 tpd mill which will replace the present smaller mill in operation at the Viny Ridge mine. Lake Asbestos of Quebec Ltd., a subsidiary of American Smelting & Refining Co. that leased the property of United Asbestos Corp., is preparing open pit operations and planning a 5000 tpd mill. The project involves draining and dredging of Black Lake, roughly 1 mile long and ½ mile wide.

The problem in asbestos milling is not only the mere recovery and concentration of valuable mineral as in most other minerals beneficiation processes, but also the recovery of maximum fiber length in order to get the benefits of the much higher prices for the more desirable products. Recent installations and tests have indicated that grinding of asbestos rock in ball mills under certain precautionary conditions may result in equal recoveries at lower operating and maintenance costs than the hammer mill type equipment generally used heretofore. Aerofall mills also have been tested and found promising.

COPPER: In normal times two developments so spectacular as Anaconda's Chuquicamata sulphide plant and the Greater Butte leach-precipitation-float plant would have held the spotlight for at least another year, but 1954 was not a normal year, with new plants at Silver Bell, Bisbee, Yerington, Copper Cities, and White Pine, and with others in construction at San Manuel, Bancroft, Chibiluma, Gaspé, and Toledo.

The 7500-ton Silver Bell flotation concentrator of Asarco at Silver Bell, Ariz., near Tucson, was tested early in March and placed in full operation within a few days. The three-stage crushing plant was designed to operate initially in open circuit but could be simply changed to closed-circuit in the last crushing stage if desirable. This change was made on July 4. One special feature of the flotation flowsheet is the flexibility of the concentrate regrinding circuit, which

Milling plays big but unpublicized role in the uranium development on the Plateau. Metallurgists find ample problems with varied and refractory ores coming in from numerous properties.

is accomplished by a combination of hydroseparator, cyclones, and thickeners. Another is the rejection of the cleaner tailing after a brief refloat in a scavenger machine. This keeps the rougher circuit entirely free of recycled material and has the added advantage that the scavenger tailing can be segregated from the rest of the tailing and later reclaimed for its high sulphur content.

The new Phelps Dodge Lavender pit concentrator with rated capacity 12000 tpd officially entered production in August. White Pine's new 12000 tpd mill near Outonagon in the Michigan Upper Peninsula started test runs late in the summer. Detailed information on these two plants will be available in 1955.

The move from Castle Dome to Copper Cities to serve the new orebody was described in a paper by B. R. Coil of Miami Copper Co. The Castle Dome concentrator was shut down early in December 1953 with foundations for the new mill at Copper Cities ready to receive equipment, buildings, and auxiliary materials. The 15-mile move was made in a carefully planned manner, and by early fall four of the seven sections were in operation with completion of the others expected before the end of 1954.

Although Anaconda's new operation at Yerington, Nev., was actually in production late in 1953 little was written on it until mid-1954. This 11,000 tpd leaching plant is especially interesting from three points of view: agglomeration, cementation, and FluoSolids roasting of sulphur ore. The following information is excerpted from an article prepared by Frank M. Monninger, general plant foreman at Yerington:

"Desliming of the ore preparatory to percolation leaching was obviated by the discovery that a high slime fraction was not to be expected and would not interfere with percolation if segregation could be prevented. This was accomplished by spraying the crushed ore as it was discharged from each of the six screen chutes. The conveyor transfer points supply the necessary mixing, the result being an agglomerated ore with uniform distribution of coarse and fines.

"Cementation is accomplished in three divisions, each containing operating and standby sections. Percolation of solution is upward through the scrap iron, and the solution overflows adjustable weirs. By this means fresh iron is brought into contact with solution by simply raising the overflow level.

"Elemental sulphur ore running 20 to 30 pct sulphur is mined at Leviathan, crushed to ¾ in. in 3 stages, dry ground to 10 mesh in rod mills, and finally burned in FluoSolids reactors. The gas is cooled conventionally and then passes to a 450 tpd contact plant."

Gaspé Copper Mines of Quebec should have its new 6500 tpd mill in operation early in 1955. The Bancroft mill of Anglo-American Corp. and the Selection Trust mill at Chibiluma, 5000 tpd and 1600 tpd respectively, in the Copperbelt section of Northern Rhodesia are under construction and expected to go into production in 1956. A 1400 tpd concentrator is being constructed for Kilembe Copper Ltd. in Uganda.

A 4000 tpd flotation plant for copper ore is under construction, and probably will start operating early in 1955, for the Toledo mine of the Atlas Consolidated Mining & Development Co. on the Island of Cebu in the Philippines. Essentials of this mill are as follows: grinding in eight Marcy 86 mills in closed circuit with Dorr DSF classifiers; removal of the oversize in the overflow by 25-ft Whirlcones; and regrinding in one 6x10-ft ball mill is closed circuit with a bowl classifier. The copper-pyrite bulk flotation concentrate will be reground and refloated.

Campbell Chibougaman Mines, Quebec, is making good progress on a 1750 tpd mill and expect to start operating before midyear.

LEAD-ZINC: The improved lead price was not enough to revive domestic lead-zinc mining and milling in 1954, and there is little to report. In the Coeur d'Alene Mining Region Asarco is enlarging the old Galena mill near Wallace to 350 tpd by addition of grinding and flotation equipment. This concentrator is adjacent to the Vulcan-Galena mine of the Vulcan Silver-Lead Co., now being developed at depth by Asarco and Day mines as a joint venture. Further north, Pend Oreille Mines & Metals Co. completed a third 800-ton unit at its Metaline Falls mill early in the year. At Telluride, Colo., Telluride Mines Inc. is planning to enlarge from 900 to 1400 tpd.

Activity abroad centers in Africa and Australia. Expected to become one of the showplaces of Tanganyika Territory in Central Africa, the new 1200 tpd lead-copper concentrator of Uruwira Minerals Ltd. will discard about half of the mill feed by Heavy-Media separation and float a bulk lead-copper concentrate from the reground sink product.

In Australia, New Broken Hill Consolidated of New South Wales has a mine and mill expansion well under way to increase ore production from the present 360,000 tons per year to 540,000 tons per year in the next two years.

In Mexico, San Francisco Mines of Mexico have recently rehabilitated the 2000 tpd lead-copper-zinc concentrator at San Francisco del Oro, Chihuahua. Reversing the normal trend, the rebuilt mill is using concentrating tables more extensively, to recover coarse lead after rod milling and again after ball milling, in order to create a flotation feed in which the copper-lead ratio will be more favorable to separation of these two metals.

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Industrial Minerals in 1954

by Robert C. Stephenson

IN 1954, a year when general industrial production declined, it is significant that industrial mineral products continued in high demand. Phenomenal growth of the cement industry, increase in filler-fibre markets such as for asbestos and diatomite, expansion of the gypsum industry, and the increasing production of agricultural raw materials all illustrate the vitality of industrial minerals fields.

Pioneer development of new industrial raw materials—wollastonite as a current example—requires keen foresight, hard work, and tremendous intestinal fortitude. The present-day requirements of industry for rigid quality control and uniformity of raw materials have resulted in highly specialized and refined methods of beneficiation in the production of many industrial mineral products, as witnessed by the many multimillion-dollar plant investments of recent years.

The future is optimistic. Ceramics are on the threshold of many developments in the intriguing field of *cermets*. Many new things are to come in the field of glass and glass fibres, and industrial minerals are essential in the rapidly developing usage of reinforced plastics. Industrial mineral products account for an ever-increasing percentage of the building materials utilized in modern construction. A host of the lesser industrial minerals and rare metals will be essential to future developments such as those of the electronic age.

Industrial Minerals Commodity Review

ASBESTOS—Most spectacular raw material production development in the asbestos field was the September 1954 inauguration of production by Johns-Manville Corp. at the world's largest asbestos mill serving the world's largest asbestos mine—the Jeffrey—at Asbestos, Que. By 1956, this mill will be producing one third of the Free World's requirements. Featured in the mill design is an elaborate dust handling system capable of filtering 2.5 million cfm.

Johnson's Asbestos Co. opened a new mill in mid-1954 with a crude ore capacity of 4000 tpd from its newly developed Megantic mine in the Black Lake area of Quebec. The Lake Asbestos of Quebec Ltd., a $20 million project, is progressing with the dewatering of Black Lake, the open pit development of the asbestos deposit beneath the lake, and the construction of a 5000-tpd mill. Asbestos Corp., now operating four mills with a combined capacity of 14,000 tpd crude, will have a new 5000-tpd Normandie mine. Quebec Asbestos Corp. located a large deposit of asbestos, first estimates of which indicate 40 million ton reserves, along the Pennington Dike, 15 miles northeast of Thetford, Que. The deposit will be developed as the open pit Carey mine to supply a mill of approximately 2000 tpd capacity. Relocations Ltd., a company composed of Asbestos Corp., Johnson's Co., and Bell Asbestos, was organized to relocate the southern part of the town of Thetford, 1 mile of highway, and 8½ miles of railroad, and make available large reserves of high grade asbestos.

Ontario's only asbestos operation, the Munro mine of Johns-Manville, opened late in 1950, is nearing the end of open pit ore reserves and is sinking an 800-ft shaft in an underground development program expected to be producing by 1958.

Cassiar Asbestos Corp. has swung into full production at its British Columbia development at an estimated rate of 10,000 tons of high quality spinning-grade of asbestos fibre per year. Cassiar fibre has an average total iron content of 1.6 to 2.0 pct as compared with 2.0 to 2.7 pct in the average nonferrous Southern Rhodesian fibre. Magnetic rating for the British Columbia fibre is 0.8 to 1.1 pct, while that of the Rhodesian fibre is 1.2 to 1.4 pct. In the Cassiar spinning fibre, North America appears to have a material equal or superior to the standard nonferrous Rhodesian fibre which has been in short supply during periods of emergency.

During the past field season, Canadian Johns-Manville was exploring deposits of crocidolite, or blue asbestos, on the iron ore properties of Hollinger-North Shore Exploration Co. on the Quebec-Labrador border. A commercial discovery of crocidolite could be of great strategic importance to the Western Hemisphere, since the Free World is dependent upon the deposits of *Cape blue asbestos* in South Africa for this type of fibre.

In Southern Rhodesia, at Mashaba, late in 1954, Rhodesian Asbestos Ltd. opened a new processing plant with a capacity of 20,000 tons of fibre per year. The crude fibre is being derived from the recently developed Temeraire and Shamala mines. Rhodesian Asbestos Ltd., which is owned by a combine of Canadian Johns-Manville Co. Ltd., British Metals Corp. Ltd., Anglo-Huronian Ltd., and the Simon I. Patino interests, is operated under direction of Canadian Johns-Manville. Small operators in Africa continued to feel the *soft* market conditions which developed in 1953.

On the domestic production front, the General Services Administration stockpile depot at Globe, Ariz., was authorized to accept nonferrous chrysotile asbestos up to 1500 tons of grades No. 1 and/or No. 2. On Sept. 30, 1954, 617 tons of No. 1 and No. 2 grades had been delivered against the 1500-ton objective, together with 320 tons of No. 3 grade.

The great expansion of asbestos production in Canada will make available adequate supplies to meet all existing market needs and provide sufficient surplus, probably at more favorable prices, to encourage new product applications.

CEMENT—The industry presents one of the most optimistic pictures of all mineral industries. In 1954, the cement industry reached an all-time peak in production, with 265 million bbl of cement for the 12 months

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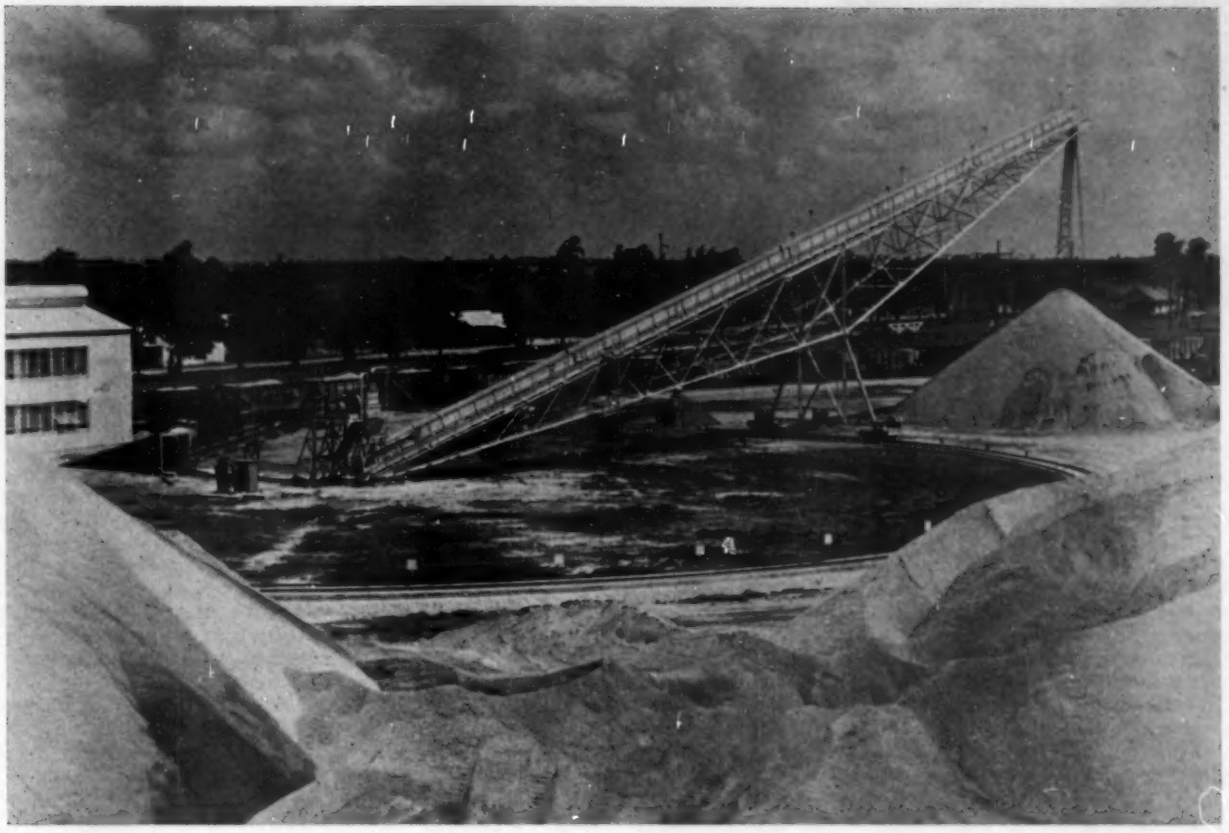


ending Aug. 31, 1954, an increase of 1 million bbl over the record year of 1953, according to statistics of USBM. The 1954 production was materially affected by a strike which closed a number of the Eastern mills early in the year. As the year ended, the cement industry was operating at 103 pct of capacity.

The 1954 record of the cement industry, in the face of protracted steel production and a lower level of general business activity, is also reflected in the optimism with which the industry is facing the future. An industry-wide expansion program scheduled over the next five years is expected to increase the existing industry capacity of 290 million bbl by 20 pct at a total cost of $400 million.

Throughout the country, companies large and small are modernizing equipment and increasing capacity of existing plants. Plans for four new Portland Cement plants in the Southwest were announced during 1954, and construction of a new plant was begun in Alabama.

In Canada, the cement industry has doubled its capacity since World War II to a figure of 25 million bbl annually. New facilities in Quebec, Manitoba, Alberta, and British Columbia will raise this figure. The Mitchell Engineering group of London is reported to have formed a new Canadian company, Mitchell, Foss, Montreal, to manufacture slag cement, known in Europe as Trief cement.

Technologically, the trend toward dry process in cement manufacture was further stimulated in 1954 with the successful installation of a German-developed suspension preheater for dry kiln feed at an eastern Pennsylvania plant. Quality control of raw materials through beneficiation continued to receive wider attention, particularly in the old producing areas where raw material reserves present increasing problems.

DIATOMITE—The industry operated at full capacity during 1954, with three major companies of the industry contributing the bulk of the production. These were the Johns-Manville Corp. at Lompoc, Calif.; the Great Lakes Carbon Corp. at Walteria and Lompoc, Calif., Terrebone, Ore., and Basalt, Nev.; and the Eagle-Picher Co. at Clark, Nev.

A recent discovery of diatomite in a potential residential area in the Palos Verdes hills near Walteria, Calif., made it necessary for the Great Lakes Carbon Corp. to acquire large acreage. It has been reported that portions of the area may be subdivided for residential purposes by the company, thus placing them uniquely in the real estate business.

In eastern Oregon both Great Lakes Carbon Corp. and the Johns-Manville Corp. are reported to have leased acreage in the Otis Basin area of northern Harney County. Some exploration was also done in the Harpor diatomite district in northern Malheur County.

Foreign production of diatomite continued at a relatively high level, with Denmark, Germany, France, and Japan being major producers. Currently U. S. producers have the advantages of high grade deposits and highly developed facilities.

Expansion of existing markets and development of new uses continued with prices remaining stable in 1954. Newer applications included drilling mud, well cement, aggregate, concrete mix, insecticide, and paint filler. Johns-Manville is building a plant at Lompoc to produce synthetic silicates by hydrothermal reaction processing.

FLUORSPAR—There was a severe shakedown in 1954, when increased foreign supplies and sharply decreased requirements for metallurgical spar brought lower prices and consequent trouble to domestic producers. New and enlarged foreign facilities were producing greatly increased quantities of fluorspar that were offered at prices that could not be matched by many higher-cost domestic operations. Decline of steel production to 60 pct of capacity reduced consumption of metallurgical-grade spar although the demand for acid-grade spar continued strong. Chemical uses exceeded metallurgical use for the first time in 1954.

St. Lawrence Fluorspar Inc. began production in its acid-grade concentrating plant located on tidewater at Wilmington, Del. The mill, which has a capacity of 300 tpd of crude ore, derives its supply principally from Newfoundland with lesser amounts from Italy and other foreign sources. Output of the plant, which

Amazing growth of cement making capacity is calling for more and larger equipment. Built by Nordberg Mfg. Co., the mill is one of largest in the Portland cement industry. One of five, this 9 ft 6 in. x 34-ft wet grinding mill has direct coupled 1500-hp synchronous motor, weighs over 400,000 lb.

was built with the aid of a Government loan, is to go to the U. S. Government stockpile under a contract calling for delivery of 150,000 tons or acid-grade spar in a four-year period. Ceramic-grade fluorspar promises to be an important factor in St. Lawrence Corp.'s activities.

Mexico continued to gain prominence in the fluorspar picture. The Encantata plant of American Smelting & Refining Co., in the Rosita district of Mexico, went into production in July 1953 with a rated capacity of 2200 tons per month and constituted the major source of Mexican acid-grade material. Availability of the Mexican production has been a principal factor in depressing the price of acid-grade spar from its all-time Korean War high of $65 per ton. Asarco also entered the market in mid-1954 with metallurgical fluorspar from the Paila district. Active prospecting for fluorspar was reported near the city of San Luis Potosi. The San Luis Mining Co. is reported to have diamond-drilled north of Nacozari, Sonora. An in-bond Heavy-Media separation plant for the upgrading of Mexican fluorspar ore is expected to go into operation at Brownsville during the first half of 1955. The Mexican ores have the advantage of direct rail shipment via Eagle Pass, Texas, or low-cost barge transportation from Brownsville to Gulf Coast and Mississippi River points.

Near the end of 1954, announcement was made of a $400,000 Export-Import Bank loan to Fluoruros S. A., leading producer of fluorspar in Spain, for partial financing of a $1 million development program including a 400-tpd Heavy-Media separation plant in the Pyrenees. Shipment of fluorspar concentrates is expected by the first half of 1955.

Facing the possible exhaustion of mineable reserves within ten years, the state-owned cryolite mining company at Ivigtut, Greenland, embarked on an exploration program and was studying means of beneficiating existing reserves of low-grade material.

In 1955 supplies of fluorspar should be more than adequate for all needs, but pressure of abundant low cost foreign material promises to continue to rule the market to the distress of the domestic industry.

GRAPHITE—Domestic production of strategic grades of graphite was greatly curtailed in 1954. Southwestern Graphite Co. at Burnet, Texas, capable of producing 25 pct of the nation's requirements of flake graphite, shut down operations in January 1954, because of poor markets. Limited shipments were continued from existing stocks. The Government-owned plant built during World War II at Chester Springs and operating on contract, discontinued operations in December 1954. Low grade of the crude flake graphite ore and difficulties in beneficiation were reported as problems. In Alabama, the Hayworth Graphite Co. continues to operate a graphite mill, but the Alabama Flake Graphite Co. has ceased to operate its Clay County deposit. Near Cranston, R. I., the U. S. Graphite Co. was reported producing a graphitic product for foundry facings from an impure coal. The Black Donald mine in Canada, which had produced substantial quantities of graphite in recent years, closed in mid-1954.

Strategic graphite was in short supply during the Korean War, because of limited supplies available from Madagascar. As a result of our Foreign Aid Program, Madagascar graphite production potential was increased through mechanization and development and now exceeds world requirements. As a result, a buyers' market with decreasing prices has prevailed in 1954.

A new flake graphite mine near Thica, Kenya Colony, South Africa, began production at the rate of 50 tons per month.

Mexico continued as the leading producer of amorphous graphite, but some users were experiencing difficulty in obtaining adequate supplies. As a consequence, there was an increase in amorphous graphite imports from Norway, Germany, Hong Kong, and other points. Small quantities of amorphous and flake graphite were available in 1954 from Korea.

The Malone Committee reported that the Western Hemisphere could be self-sufficient with respect to strategic graphite, but that research was needed to develop more efficient mining and milling of domestic sources.

GYPSUM—Production in 1954, with an estimated total of 11.5 million tons of gypsum rock mined, showed a healthy increase of 300,000 tons over 1953. Production in 1954 was exceeded only by the banner year 1951, when 12 million tons were mined. Production of gypsum wallboard, lath, and sheathing in 1954 reached an all-time high of 6.3 billion sq ft, exceeding the 6.1 billion production in 1951 and 1953.

National Gypsum Co. is anticipating production of more than 1 million tons of gypsum rock from deposits at Dutch Settlement, Nova Scotia, near Halifax, beginning in 1955. The cost of mine development and pier facilities in Bedford Basin are reported at $6 million and will provide a 200-year supply of gypsum rock for the company's East Coast plants. A fleet of self-unloading cargo vessels will provide transportation. A new gypsum products plant was completed at Montreal that utilizes gypsum rock from Nova Scotia and New Brunswick. In western Canada, the British Plaster Board Co. of London has purchased plasterboard and wallboard plants at Winnipeg and Calgary and gypsum deposits in Manitoba and British Columbia.

In the U. S., the most important activity was centered in the area near Mitchell, Ind., where recently discovered gypsum deposits were being delineated by U. S. Gypsum Co., National Gypsum Co., and Ruberoid Co. Mine and plant development plans are under way.

The Ruberoid Co., largest manufacturer of prepared roofing in the country, entered the gypsum field in 1954 with the Ebsary Gypsum Co. of New York. In Utah, the two gypsum plants were running around the clock to meet demands of the building industry in the Intermountain and Pacific Northwest areas. Ocean shipment of crude gypsum from San Marcos Island in the Gulf

of California to a gypsum products plant in Seattle began late in 1954 and promises to create a readjustment of marketing areas in the Pacific Northwest. Large-scale shipments of gypsum rock to Jacksonville, Fla., from U. S. Gypsum Co.'s recently acquired Jamaica facilities also began during the year. Certainly the most significant trend within the industry is the development of deposits near tidewater and the use of low-cost ocean transportation in bulk movement of crude gypsum.

Recent and current research activities of the industry include development of a new type X gypsum wallboard with extra-high fire resistance, lightweight fireproofing systems, and ready-mixed, lightweight aggregate plasters.

The outlook for gypsum production in 1955 appears favorable in the light of home building activities. Use of ever-improving gypsum products is extending also to fields of commercial and industrial construction.

LITHIUM—Phenomenal growth of the industry over the past five years was stimulated tremendously by integrated expansion undertakings of three major lithium producers.

The Foote Mineral Co. announced expansion of its spodumene mining and beneficiation facilities near Kings Mountain, N. C., and an increase in capacity of the chemical processing plant at Sunbright, Va., at a cost of several million dollars. The expansion programs at Kings Mountain, completed in the fall of 1954, and at Sunbright, establish these facilities as the world's largest lithium producers.

Also in the Southeast, Lithium Corp. of America Inc. began construction of a $7 million integrated lithium refining plant at Bessemer City, N. C., scheduled to go into production during the first half of 1954. Part of the raw material for this plant will come from company spodumene deposits in North Carolina. Additional ore for Lithium Corp.'s Bessemer City, N. C., and St. Louis, Minn., plants will come from spodumene deposits now under development near Val d'Or, Que. This new source is the result of a five-year supply contract signed by Lithium Corp. of America and Quebec Lithium Corp., a subsidiary of Sullivan Consolidated Mines Ltd. Quebec Lithium is anticipating underground production of ore by late 1955. The spodumene ore will be beneficiated before shipment in a 1000-tpd plant now under construction. The Val d'Or deposit consists of spodumene-bearing zones in pegmatite dikes ranging from 10 to 100 ft wide and traceable in some instances for as much as 8000 ft along the strike. Reports indicate reserves of 10 million tons of 1.3 pct LiO_2 ore.

Late in 1954, a third major development in the lithium industry was announced by American Potash & Chemical Corp., already a producer of lithium carbonate from brines at Trona, Calif. A plant to produce lithium hydroxide will be constructed near San Antonio, Texas, by a newly formed company, American Lithium Chemicals Inc. This company will be owned jointly by American Potash (50.1 pct) and Bikita Minerals Ltd. (49.9 pct), and Bikita will supply ore for the new plant from a high grade lepidolite deposit in Southern Rhodesia. Bikita Minerals Ltd. is owned 50 pct by the Selection Trust Ltd. of London, responsible for its technical direction, with balance of control by American Potash Co., and the American Metal Co. Ltd. Expansion of the Rhodesian mine, which is already shipping limited quantities of lepidolite, and construction of the San Antonio processing plant, to be completed in 1955, will cost an estimated $8 million.

The boom in lithium demand and the resulting major developments in 1954 stimulated exploratory activity throughout the world. Northwest of Winnipeg, Man., Lithium Corp. of America acquired 51 claims on which limited exploration has been reported to have blocked out over one half million tons of milling-grade spodumene ore. Lithium properties have been explored and acquired by a number of interested companies in various areas throughout the world. In Southern Rhodesia, the Lepidolite Development Corp. Ltd. has acquired and done limited development work on rich lepidolite deposits near Salisbury. Production of several hundred tons per month direct shipping ore from this source is reported to be possible in the near future.

Expansion has been the rule in industrial minerals production and asbestos is no exception. This open pit at Munro mine, Ontario, is being replaced by underground production.

A prolonged dry spell caused the Lithium Corp. of America to close its Black Hills operation in July 1954, due to lack of water, and several months of much-needed lithium ore production was lost.

Expansion of the industry in 1954 resulted from a steady increase in civilian and defense requirements for lithium products, but production figures are shrouded by security regulations. It has been estimated that the use of lithium in lubricating greases could be doubled and use in ceramics possibly trebled if supplies were readily available. Other new and expanded usage is probable with more abundant supplies and somewhat lower prices. A competitive marketing battle among the major lithium producers may be shaping up as the current expansion programs are completed, for at least some authorities on lithium feel that an excess of capacity may then be available. In December 1954 Foote Mineral Co. announced a reduction of 15¢ per lb in the price of lithium hydroxide, reflecting economies resulting from expanded facilities.

(See also section Lithium, p. 249, in Mining Geology review.)

MICA—Imports decreased during the first three quarters of 1954 and strategic mica remained on the Government stockpile critical list. India, the largest supplier, was experiencing production difficulties, and in Brazil inflationary conditions slowed down supplies. In mining of strategic mica, 10 to 20 pct of the yield is strategic quality and 80 to 90 pct is mica of nonstrategic grades. With the existing stockpile price schedule for strategic mica, the producers must also market nonstrategic grades at fair prices to operate at a profit. With the market for nonstrategic grades of mica off in 1954, the flow of strategic mica for stockpiling was sharply curtailed.

GSA established a schedule for the purchase of domestic nonruby mica in November 1953. In May 1954, prices on nonruby, good stained, or better grades were raised 20 pct to equal those of comparable ruby grades. Domestic mica purchases at GSA depots through the third quarter of 1954 were:

Depot	BLOCK		HAND COBBED	
	Ruby*	Nonruby*	Ruby	Nonruby
Spruce Pine, N.C.	213,833 lb	34,297 lb	—	—
Franklin, N. H.	38,220	149	260,422	22,366
Custer, S. D.	20,589	94	816,114	5,715

* Full-trimmed

(Continued on page 274)

Peteca Mining Corp., operated by a Catholic order, Brothers of the Christian Schools, announced construction of a $300,000 mica mill near Santa Fe, N. M. The mill, with a capacity of 300 tpd of crude ore and 60 to 75 tons of salable mica product, was expected in operation in 1955. The Blue Ridge Mica Co. was completing a new dry-grinding plant near Penland, Mitchell County, N. C., which is expected to produce 1000 tons of ground mica per month. The Minerals Processing Co. completed facilities in Georgia for production of dry and water-ground mica, kaolin, and beryl.

In 1947 the USBM began a research program on synthesis of mica at Norris, Tenn., which led to the internal resistance melting process that will yield synthetic mica crystals up to 2-in. diam. From July 1953 to March 1954, the USBM worked cooperatively with the Mycalex Corp. of America on engineering phases of synthetic mica production. In November 1954, this company announced that a subsidiary, the Synthetic Mica Corp., would begin the world's first commercial production of synthetic mica in a plant under construction at Caldwell, N. J. Synthetic mica will be ground and will replace ground scrap mica in a glass-bonded mica product produced by Mycalex. The synthetic mica product is superior to the natural mica, so the added cost is justified. In the production process, it is possible to control the dielectric and physical properties of the synthetic mica which also has a temperature advantage of about 400°F over natural mica.

The USBM is continuing synthetic mica research at Norris, Tenn., but researchers believe that production of large sheets of synthetic mica may be as much as ten years off. A more promising solution would appear to be built-up mica sheets formed from ground synthetic mica bonded by high temperature and pressure. The work of the USBM in this field shows that the synthetic mica, which lacks the hydroxyl radical, can be so bonded through grain growth, whereas the natural hydroxyl-containing mica does not permit such grain growth.

PHOSPHATE—Early figures indicated that phosphate production in 1954 was about the same or possibly slightly higher than the 12.5 million-ton production in 1953. In the western phosphate fields, 1954 production was estimated in excess of 2.2 million tons, with good prospects for continued volume production.

In the Florida fields the Davison Chemical Co. completed its triple superphosphate plant at Bartow, with a rated capacity of 200,000 tons per year (MINING ENGINEERING, July 1954). Improvement of mining and milling equipment and methods continued and development of uranium extraction from Florida phosphate ore was reported to be progressing, but not without problems.

In Tennessee, the Shea Chemical Co. Inc. began processing its own phosphate rock, and at Columbia, Tenn., the Mines Equipment Co. was installing a phosphate rock washing plant. The Tennessee Valley Authority offered its Tennessee phosphate rock washing and drying facilities for sale.

In the Rocky Mountain area active exploration continued, particularly for deposits which could be developed as open pit mines. Westvaco Mineral Products Div., Food Machinery & Chemical Corp., which has been buying phosphate rock from J. R. Simplot for the plant at Pocatello, Idaho, acquired land with phosphate reserves reported at over 1 million tons in Rich County, Utah. This deposit is expected to supply requirements of the Pocatello plant when brought into production. San Francisco Chemical Co. started two mines in the Rich County, Utah, area. Electric furnace production of elemental phosphorus at Pocatello and Soda Springs, Idaho, was expanded and improved during 1954. Jefferson Lake Sulphur Co., late in 1954, announced plans for a $3 million plant in southeastern Idaho to produce 80,000 tons per year of triple superphosphate, and Western Phosphates Inc., Garfield, Utah, was expanding its triple superphosphate capacity. The USBM was cooperating with Montana Phosphate Products on a study of continuous mining methods for phosphate rock.

The market for dicalcium phosphate was off, and that for superphosphate static. Triple superphosphate use was up sharply and indications were that the trend would continue in 1955.

POTASH—The industry had a banner year in 1954. The major producers entered the year with sizable stockpiles which were absorbed in the market during the spring season.

The most important development came when two groups, new to the potash industry, entered the field with developments in the Lea-Eddy County area of New Mexico, northeast of Carlsbad. Freeport Sulphur Co. was reported to be joining forces with the Pittsburgh Consolidation Coal Co. for a $16 million project. The National Farmers Union and Kerr-McGee Oil Industries are to form a new corporation for development of potash holdings. International Minerals & Chemical Corp. is reported also to hold substantial acreage in this new area.

In Canada, Potash Co. of America, after several years of intensive investigation, chose two areas for further prospecting. Just east of Saskatoon the company is preparing to sink a 15-ft diam shaft. The other area is immediately west of the Quill Lakes. Western Potash has reached a depth of about 1000 ft with its shaft near Unity. DuVal Sulphur & Potash Co. entered the Canadian picture in 1954 by acquiring options on four large tracts of land for exploration. Little data has been released on the grade and extent of these deposits which underlie the Saskatchewan prairies at depths of 3000 to 4000 ft.

At Astrain near Pamplona, Spain, recent drilling is reported to have proven a potash deposit extending over an area of 52 sq km. Details are lacking as to the depth and quality. Israel began shipping potash late in 1953 to England and other European countries, but plant difficulties hampered 1954 production, which was reported at 2500 tons per month in mid-1954.

Mine mechanization was still an important trend among the domestic potash producers. Increased production was effected by improved methods of pulling pillars. Potash Co. will install a conveyor system 7¼ miles long to handle ore produced by continuous mining machines. This same company has in operation a flotation pilot plant employing a new technique.

During 1954, the Potash Export Assn. Inc. was formed by major producers to develop greater foreign business. The industry adopted a policy of competitive pricing f.o.b. U. S. ports to meet the export market. Seasonal discount prices have been dropped in favor of lower prices quoted to off-season buyers. The Treasury Dept. referred to the Tariff Commission for study and a ruling on the problem as to whether potash imports from East and West Germany, France, and Spain are harmful to the domestic industry and are to be subject to tariff regulation under the Anti-Dumping Act. As the industry faced the future, there was a strong possibility of world oversupply of potash.

SULPHUR—This keystone of industry was in plentiful supply to meet all domestic and export requirements in 1954. Production rose 350,000 tons over 1953 in the U. S. to an all-time high estimated at 6.6 million tons. Frasch process sulphur from 13 salt dome producers on the Gulf Coast accounted for 83 pct of the production; sulphur from pyrites, 6 pct; sulphur from refinery by-product and natural gases, 5 pct, and byproduct sulphur from other miscellaneous sources, 6 pct.

The new Garden Island Bay operation of the Freeport Sulphur Co., which was completed late in 1953, produced over 9 pct of the total Frasch sulphur and was largely responsible for the 300,000-ton increase of Frasch sulphur over 1953. Another Frasch process plant is being developed on the Chacahoula salt dome in Louisiana.

Standard Sulphur Co., a newcomer to the field, began production at its Damon Mound property near Rosenburg, Texas, in the last quarter of 1953, utilizing a mobile plant adapted to the production problems of the

One trend in industrial minerals field is to higher grade product, closer quality control, through increased beneficiation. Silica sand from these dunes is cleaned by flotation. Elsewhere Heavy-Media is getting attention from the aggregates producers.

deposit. In 1954 the company brought the capacity of its Damon Mound facilities to 350 to 400 tpd. A mobile plant is also to be installed on Bryan Dome, Brazoria County, Texas, by Standard Sulphur and other expansion plans are under consideration. Exploration and development of Mexican Gulf Coast sulphur deposits continued to be active. Pan-American Sulphur Co. anticipates production of 400,000 to 600,000 tons per year from the Jaltipan, Vera Cruz, operation which began in October 1954.

After years of geological studies followed by core drilling, the salt domes of the Isthmus of Tehuantepec, Mexico, are finally coming into production. During the year the Mexican Sulphur Co. at San Cristobal completed the first Frasch process sulphur plant outside the U. S., and now has production of 200 tpd. Gulf Sulphur Co. has a plant under construction anticipated to produce 400,000 tons per year. A bare 10 pct of the potential area of each company has been drilled. Mexican Sulphur has found recoverable sulphur as close as 600 ft to the surface. (Data from W. J. Shedwick, Jr.)

The Leviathan volcanic sulphur deposit was an important supplier of Anaconda's sulphuric acid plant at Yerington, Nev. At San Felipe, Baja California, Mexico, a volcanic sulphur deposit was brought into operation in mid-1954 by Texas International Sulphur Co. In Peru, Fluor Peruana S.A. was reported planning a development of sulphur deposits and there was exploration and development activity in Venezuela. The volcanic sulphur industry of Chile which flourished during the recent sulphur shortage was virtually at a standstill, a victim of high operating costs and a competitive market. A combine of sulphur-consuming industries in Japan developed volcanic sulphur deposits in Hokkaido Province and installed an 18,000-ton per year refining plant. The brimstone deposits of Sicily made news when workmen conducted a protracted underground sit-down strike which seriously reduced 1954 production.

In the U. S., ten projects for recovery of sour natural gas, byproduct refinery gases, and other byproduct sources were completed. By 1955, one source estimates that 100 or more new production units for byproduct sulphur recovery, undertaken because of the sulphur shortage, would be placed in operation throughout the Free World. In addition to the byproduct sulphur production of the U. S., Shell Oil Co. is completing a new plant at Jumping Pound, Alberta, to produce 11,000 tons annually of sulphur from sour gas, and Royalite Oil Co., a plant at Turner Valley, 10,000 tons, bringing the annual sulphur production from sour gas in Alberta to 32,000 tons.

In Canada seven pulp mills have installed equipment to produce sulphur dioxide from pyrites for making bisulphate liquor. Noranda Mines Ltd., in the last quarter of 1954, brought into production a $4 million plant at Port Robinson, Ont., to process 100,000 tons a year of pyrite-rich ore from the Horne mine at Noranda. Production of 18,000 tons of elemental sulphur and 36,000 tons of sulphur in the form of sulphur dioxide each year is expected. Rico Argentine Mining Co. announced plans for a $1.5 million, 200-tpd sulphuric acid plant at Rico, Colo., using pyrites from existing lead-zinc tailing. The acid is to be utilized in uranium processing on the Colorado Plateau.

Spanish interests have purchased control of the Rio Tinto Ltd. copper-pyrites holdings in Huelva Province for a reported $25 million. Annual pyrites production of this company is in the range of ¾ to 1 million tons. In Italy, the biggest producer, Montecatini, continued to expand its developed pyrites reserves. The new concentrating plant of Boliden Mining Co., Sweden, started in 1954, is expected to yield over 400,000 tons of pyrites per year, which will be converted into elemental sulphur and sulphur dioxide for domestic use. In the Harz Mountains of East Germany, expansion of pyrites production is reported to develop about 122,000 tons annually beginning in 1955. In Australia, three new sulphuric acid plants now under construction will use pyrites from Queensland, N.S.W., South Australia, and Tasmania and will produce a total of 500 tons additional sulphuric acid daily.

TITANIUM—The metal—with much fanfare—was in the news in 1954, but the more prosaic industrial mineral applications of titanium still dominated use.

In the raw material field, Du Pont Co. constructed its new Highland Plant, 10 miles north of Starke, Fla., expected to be in production early in 1955. The plant, handling 100,000 tons of finished ilmenite concentrate per year, is expected to double Du Pont's productive capacity. The deposit is on Trail Ridge and is in effect a northward extension of the deposit east of Starke which Du Pont has mined since 1950.

At Aiken, S. C., the Crane Co., with Perry Minerals Co. and Callahan Zinc-Lead Co., is installing a bucket-line dredge and heavy mineral separation plant for the recovery of rutile, ilmenite, monazite, and zircon from a placer deposit in the Aiken Plateau area. The dredge is expected to be in production early in 1955 and the separation plant by April. Titanium ore from this plant is to supply in part the requirements of the new Cramet titanium metal plant at Chattanooga.

Biggest news in titanium exploration was the large primary rutile deposit 30 miles from Port Angelo, Oaxaca, Mexico, held by Republic Steel Corp. The deposit may be the largest known reserve of rutile in the Western Hemisphere. It is reported to be 7 miles in length and ½ mile wide, containing over 25 million tons of rutile ore running 15 to 20 pct TiO_2. It will be worked by underground methods. The rugged terrain of the isolated area will present problems of supply and transportation. Production at a rate of 2000 tons of finished rutile concentrate is scheduled to begin in early 1956. At Ilmenite Hill, near Durban, South Africa, production began from a deposit of ilmenite, rutile, and zircon. Another source of ilmenite ore was reported under investigation at Morgan Bay in eastern Cape Province.

There was considerable exploratory activity in titanium during 1954. Bear Creek Mining Corp., a Kennecott subsidiary, is reported to have conducted extensive exploration of Florida placer deposits. Crane Co. has been negotiating for similar deposits on the Gulf Coast and Panama City area. Union Carbon & Carbide is reported interested in ilmenite deposits north of Laurenco Marques, Portuguese East Africa. Exploratory activities of the Union Pacific RR continued to draw attention to the titaniferous magnetite deposits of Laramie Range, Wyo. In the Lake Sanford area of the Adirondack Mountains, New York, the National Lead Co. found encouraging results in continuing exploration. Hawaiian deposits containing anatase attracted some exploratory interest during the year.

Quebec Iron & Titanium Corp. continued production of high-titania slag by electric furnace smelting at Sorel, but the plant continued to operate at a loss in 1954. The plant, rated at 660 tpd of slag and 480 tpd of iron, did not reach capacity production.

Glidden Co. began construction of a $10 million titanium dioxide plant at Baltimore late in 1955.

The Australian rutile market rallied during the closing months of 1954 and, as the year closed, supplies for delivery in the first half of 1955 were tight.

Production of titanium metal exceeded 5000 tons in 1954, more than double that of 1953. The Defense Dept. set a goal of 30,000 tons of titanium metal per year within three years. Du Pont, Union Carbon & Carbide, Cramet, and Dow Titanium Metals Corp. have contracts for production under this program. Japan assumed a prominent place in the titanium metal field with an aggregate production reported at about 1200 tons per year, for the most part exported to the U. S. and England. Imperial Chemical Industries were reported building a 1500-ton plant in England. During the year, the price of titanium metal was reduced from $5.00 to $4.72, then to $4.50 a lb in December.

Horizons Titanium Corp., Kennecott Copper, Monsanto Chemical, and others were reported to have active titanium metal production experiments under way. From Canada and Japan came reports of successful reduction of titanium dioxide with calcium metal to produce titanium metal powder. Shawinigan Water & Power Co., Montreal, announced a low-cost laboratory-tested, electrolytic method for making titanium metal. The method involves electrolysis of titanium tetrachloride in a fused salt electrolyte. The Fulmer Research Institute in England announced a potentially important laboratory development of a continuous method of titanium metal production by catalytic action. This method is to be tested in a pilot plant. Also in the laboratory, a method was successfully developed for plating of titanium metal on steel that promises to be important if it can be commercially applied where anti-corrosive properties of titanium are desirable. In Japan, a new alloy called *titanize*, consisting of 95 pct aluminum and 5 pct titanium, for use in the surface treatment of steel was in limited production in 1954. The alloy surfacing is reported to impart all of the advantages of stainless steel to steel so treated and to have higher heat and erosion resistance and greater durability than aluminized steel.

Other Industrial Minerals Developments

CERAMIC MATERIALS—Fire clay production in 1954 was more or less static, in part reflecting the cutback in steel production. Emphasis on the need to develop new reserves of **flint clay** in Missouri and Pennsylvania continued. Harbison-Walker Refractories Co. is reported to have acquired valuable flint clay reserves when it purchased the Union Fire Brick Co. A. P. Green Fire-brick Co. acquired the facilities of the Thermo Fire Brick Co. at Sulphur Springs, Texas, and also bought Liptak Furnace Arches Ltd., London. In the fire brick industry, the trend is to higher grade products through improved raw materials. Low grade bauxite deposits are being calcined to produce synthetic mullite brick.

Harbison-Walker Refractories Co. began construction of a new **silica refractory** plant at Leslie, Md., using a local conglomerate as raw material.

There is an increasing trend toward low alumina silica refractories for acid processes demanding high-strength linings at elevated furnace temperatures. Beneficiated ganister, quartzose gravel, and conglomerates provide the high quality raw materials necessary for these high quality products.

Benguet Consolidated Mines Inc. increased its capacity for refractory chrome ore shipments to 40,000 tons per month and was supplying ore to industry and against a Government stockpile contract. Some difficulty was experienced with the silica content of certain ores as mined.

U. S. production of **magnesite** was down in 1954, and there was an increase in imports of caustic or calcined magnesite from Austria and Yugoslavia. Diamond Alkali closed its refractory magnesium plant, Painesville, Ohio, in mid-1954. The Northwest Magnesite Co. resumed operation of its Chewelah, Wash., plant in April. A Heavy-Media separation plant is performing an important precleaning job on the magnesite ore ahead of the kiln at this plant. A new basic refractory brick plant was placed in operation at Marelan on the Quebec-Ontario border.

A new nepheline **syenite-corundum** deposit was reported under investigation by Monteagle Minerals Ltd. in the Bancroft, Ont., area, and plans call for a 75-ton pilot plant. A 17-mile rail spur is being built by Canadian Pacific RR to the property of American Nepheline Ltd. at Lakefield, Ont. This nepheline is finding use in ceramics, as a pigment extender in paints, and as a filler material. Fluid energy grinding of nepheline is proving advantageous in that it yields a high percentage of —325 mesh material without excessive micron size fines.

In the **feldspar** industry, 1954 was marked by increased mechanization. The Consolidated Feldspar Div. of International Minerals & Chemical Corp. has successfully developed a picking bin to provide uniform feed to cobbing tables.

Scheel Olivine Inc. began production of **dunite** from large, high grade deposits on Twin Sisters Mountain in Skagit County, Wash. The olivine ore is being treated in a processing plant at Hamilton and is expected to be utilized principally as foundry sand and in the manufacture of refractory brick.

The Kyanite Mining Corp. installed new grinding and storage facilities at the Pamplin, Va., plant. Pella Refractory Ores Ltd. began commercial production from a massive corundum-sillimanite deposit in Namaqualand. Most of the current production, reported at 400 to 600 tons per month, comes from an extensive surface boulder bed. The material principally will be exported for use in refractories, but certain U. S. companies have experienced difficulty in obtaining consistent cone values in experimental firing of the material. A massive **corundum** deposit is being developed in Southern Rhodesia to meet African needs for high grade refractory brick.

One of the most important developments in the ceramics field is the rapid progress being made in the combining of ceramic materials and metals. A **cermet** may be defined as a ceramic body or coating in which an internal metal phase forms an essential part of the final composition or plays an important part in the thermal maturing process. Cermets are replacing metals in many industrial and military applications because they are more heat-resistant and cheaper. Ferrites may replace electromagnetic metals in electronic applications and ceramic coating of metals is proving highly important in jet and rocket applications. Solution ceramics applied to metals are in their infancy, but promise to open some unusual avenues of application.

CHEMICAL MATERIALS—Near Windsor, Ont., Canadian Rock Salt Co. was sinking a 1000-ft shaft at Ojibway in preparation for a large-scale **salt** mining operation to supply Central Canada and some exports to the U. S. beginning in 1955. Near Pugwash, Nova Scotia, a recently discovered large salt deposit lying at a depth of 400 ft is probably to be developed in the near future. In the U. S., the Bureau of Mines noted an increased number of inquiries from industry concerning salt deposits. Publication of a detailed geologic structure map of western Pennsylvania in connection with petroleum studies made available new data on the distribution and depth of bedded salt deposits in that state.

The West End Chemical Corp. is adding a sodium sulphate recovery unit of 50,000 tons annual capacity at Searles Lake, Calif. By mid-1955 this production is expected to ease the tight supply of salt cake. Production of salt cake from natural deposits at Saskatchewan

showed a big increase in 1954, due in part to the shortage in the U. S. and to increased demands in Canada from the kraft paper, glass, and detergent industries. The **borax** industry, which experienced a rough year in 1952, recovered in 1953 and operated at a somewhat more favorable rate in 1954. California's Searles Lake area accounts for the bulk of the world's supply of boron. The price of **iodine**, produced in the U. S. chiefly from oil-well brines, dropped markedly during 1954, forcing Japan's iodine from seaweed out of the market. **Soda ash** production from the trona deposits near Green River, Wyo., continued in 1954 at approximately the same rate as in 1953.

DIMENSION STONE & SLATE—As a result of the unprecedented damage wrought by Hurricane Hazel in October 1954, the **roofing slate** industry, as well as other roofing manufacturers, found inventories depleted and backlogs of orders.

The slate industry for the first time in a number of years reported favorable trends in 1954. As a result of a long overdue promotion and advertising campaign, slate blackboards were being used again in increasing numbers in modern schools. Scarcity of Alberene stone created a market for structural slate in laboratory furniture and another new use was in the manufacture of precision plates, or map tables. Coffee table tops of polished slate were also produced for the first time, but slate continues to suffer in the highly competitive roofing market.

New products and more economical methods of mining, processing, and application are needed if slate is to regain some of its lost markets. Experimental work on quarry sawing techniques and installation of a new three-roll sanding machine in one plant highlighted technologic developments. One company was studying feasibility of lightweight aggregate production from bloated slate waste. Minnesota Mining & Mfg. Co. was reported investigating potential roofing granules production facilities in the Somerville, N. J., area.

In 1954, the National Building Granite Quarries Assn. reported sales of **granite** curbing up 10 pct, for bridge construction up 15 pct, and granite for buildings up 15 pct. The coming year promises to be equally optimistic. One leading producer is planning a new central mill to replace three obsolete mills. The jet piercing process, still under experimental study in New England quarries, is being watched by others in the field. Use of the wire saw in finishing plants is increasing.

The Indiana **limestone** industry reported a slight increase in production over 1953 and anticipates a favorable level of business in 1955. Developments of interest within the industry are 1) use of the wire saw on hard-top and oolitic stone in two quarries, 2) the unsuccessful trial of the quarry bar drill, 3) continuing experimentation in the sawing of blocks with the chainsaw, and 4) the successful adaptation in one plant of a roller platform feeder for feeding long slabs into a diamond saw for jointing and then rolling these into a guillotine blade for chopping into various thicknesses.

In the application of **marble**, there is a trend among architects to the use of thin marble veneers in curtain wall construction as opposed to the more massive cubic block construction of the past. In a number of marble quarries, a 20-ft quarry bar mounting two 4-in. drills replaces older type channeling machines.

INDUSTRIAL WATER—The continuing pace of industrial expansion in our country has made the problems of adequate industrial water supply and waste disposal more and more acute. The current magnitude of water problems in all ramifications of industry from the producer of raw materials to ultimate consumer of finished goods has brought into focus our lack of appreciation of our water heritage, and water conservation and antipollution controls are rapidly becoming recognized as essential to future public welfare.

Mining companies, many as a result of bitter experience, are recognizing the importance of hydrologic studies preparatory to and concurrent with mine development programs. Hydrologic considerations are high on the list of many processing industries in developing new plant sites. The ground-water geologist is being called upon more and more for vital export opinion in matters relating to water supply and waste disposal. In many industrial areas, the absence of assembled, integrated hydrologic data is severely hindering efficient development programs.

Michigan Limestone Div., U. S. Steel Co., opened this new quarry in the Michigan Upper Peninsula in 1954. Low silica, phosphorus, and sulphur made the deposit attractive.

FILLERS & FIBRES—Production of ball clays and fuller's earth was about the same in 1954 as in 1953. The kaolin market, which started a steady upswing in 1945 that continued except for a break in 1952, showed in 1954 a slight increase over the 1953 production. Bentonite production in 1954 was about the same as in the previous year.

In the Georgia **kaolin** industry most important producers added investments in facilities. Enlarged capacities for calcining of clays, spray drying, and tunnel kiln drying have been developed, and progress has been made in removing fractional micron colloidal material from micron-size products. Exploration for and acquisition of deposits continued at a high rate. Due to improved methods of beneficiation and treatment, clays formerly considered worthless are now being reconsidered. Pipeline transportation of kaolin slurries from mine sites to railside mills promises to play an important factor in the economic development of clays lying as many as 25 miles from rail facilities. Special grades of kaolin, particularly for use in paints, are being developed to meet increasing demands.

A significant merger of clay interests took place in 1954, when the Attapulgus Mineral & Chemical Corp., producers of fuller's earth, acquired Edgar Bros. Co., Georgia kaolin producers. The company name was changed to Minerals & Chemical Corp. of America, with Attapulgus and Edgar Divisions. Sierra Talc & Clay Co. completed a plant at Olancha, Calif., for the production of bleaching clays for use in refining of both inedible and edible oils and for use in the insecticide industry.

Some believe the **bentonite** industry to have a large undeveloped potential market as a substitute for alum in water purification. The use of bentonite as a binder in pelletizing of taconite and magnetite concentrates promises increasing consumption.

The **talc** industry continued on a more or less even plane in 1954, with some noteworthy advancements. In New York State, the International Talc Co. purchased the Loomis Talc Co., but—under direction of International—the production of Loomis talcs will continue. The Reynolds Talc Co. commenced operation near the New York operation of International.

Sierra Talc & Clay Co. completely rebuilt its Los Angeles City talc mill and installed a fine-grinding

Raymond high-speed vertical mill to produce micronized talcs. The same company improved its storing and sorting facilities at its Yellowstone mine in Montana to meet the increasing demand for steatite talc. Tri-State Minerals at Ogden, Utah, installed a fine-grinding unit utilizing superheated steam as fluid energy for pulverizing talc. A small soapstone operation was started at Mariottsville, Md.

On Sept. 24, 1954, the Office of Defense Materials issued a new procurement schedule for **block steatite talc** with provisions for barter acquisition. Research is pointing to possible replacement of block steatite talc, using phosphate-bonded ground steatite or phosphate-bonded synthetic mica.

In the talc industry, development toward finer product sizes of 20 microns and down continued.

Aluminum Talc Co. was reported developing a pyrophyllite deposit in the Kyuguot Sound area of Vancouver Island, B. C.

A photoelectric device known as a Leukometer has been developed for measuring whiteness in lime for filler uses. The selenium photoelectric cell measures the reflectivity on a galvanometric scale for comparison with standard barite white.

The **barite** deposit at Walton, Nova Scotia, continued to be a prime factor in the industry by virtue of its proximity to low-cost ocean freight. Development of an underground mining program was undertaken in 1954 and shipments of crude barite increased over 1953 to more than 200,000 tons. Most of the barite moves to the U. S. Gulf Coast area, where it is processed for use principally in oil-well drilling mud. The J. R. Simplot Co. resumed operation of its open pit barite property in Blaine County, Idaho. The Magnet Cove Barium Corp. expanded mining facilities on a sizable barite deposit near Elko, Nev., and was reported considering the installation of milling facilities at or near the mine. A deposit of barium carbonate, or witherite, is reported to occur with fluorspar in nearly equal proportions in a deposit on the Alcan Highway near Liards Crossing.

The newly completed **wollastonite** processing facilities of the Cabot Mineral Co., near Willsboro, N. Y., underwent a shakedown period in 1954, and has achieved uniformity of product. Because wollastonite is a completely new industrial mineral, market development has been slow, but some important large-scale uses are anticipated beginning in 1955. Wollastonite from deposits in the Blythe-Midland area of California has been under study as a potential ceramic material.

MINERAL AGGREGATES—The mineral aggregate and related industries in 1954 continued to reflect the high rate of general building and highway construction. Prospects in 1955 are promising.

Production returns for the first eight months of 1954 show an upward trend in sales of both **agricultural and building lime,** and a decrease in use of chemical and industrial lime. Dead-burned dolomite reflected the lower level of steel production.

A significant advancement in the hydration of dolomitic lime has been made with the introduction of a new hydrator equipped with a heat exchanger that automatically retains the slow-hydrating oxides for a longer reaction period.

The **aggregate** industry is producing materials of constantly improving specifications through the use of more advanced processing plants. Heavy-Media was first employed by the Royal Canadian Air Force as a means of removing deleterious shale from glacial gravel in 1948, and has since been successfully utilized in the U. S. The Dravo Corp. of Pittsburgh has a barge-mounted H-M unit operating on buried glacial valley-fill deposits dredged from the Ohio River, and in Minnesota the Owatonna Aggregates Corp. is reported to be considering additional H-M facilities based on the success of its first unit in treating glacial gravels. In Pennsylvania, one company was investigating H-M application for the reduction of silica in a dolomitic limestone. In the future, Heavy-Media separation will undoubtedly be more widely used in the treatment of glacial deposits, thin, interbedded dense and soft rock, and other heterogeneous deposits.

One of the biggest stone developments during 1954 was the Cedarville, Mich., quarry of the Michigan Limestone Div., U. S. Steel Corp., from which shipments of a low silica dolomitic fluxstone are expected to begin in the spring of 1955, using dock facilities on Lake Huron. This same company abandoned its underground, high-calcium limestone mine at Annville, Pa., due to costly mine water problems, and the property was sold to the nearby Hershey Chocolate Co. as an industrial water reservoir. As the mine filled with water when pumping ceased, adjacent quarrymen immediately experienced serious new water difficulties.

The Ideal Cement Co. was reported to be planning production of aggregate materials at the Laramie, Wyo., experimental alumina plant purchased recently from the Government. The Standard Lime & Stone Co., a diversified producer of industrial minerals, was sold in November 1954 to the American-Marietta Co. for a reported $10 million. The Northwest Portland Cement Co. is developing a new 50 million-ton reserve of limestone near Lake Wenatchee, Wash., to supply its Grotto cement plant.

National Industrial Products carried out extensive diamond drilling and bulk sampling in the development of a large, high grade **limestone** deposit adjacent to the Union Pacific RR near Durkee, Baker County, Ore., and installed a processing plant to supply approximately 500 tons of limestone to the heavy chemical and metallurgical industries of the area.

The Zonolite Co. is building a new **vermiculite** processing plant at Enoree, S. C., and has acquired vermiculite expanding facilities in Elwood City, Pa., and North Billerica, Mass. The use of lightweight aggregates in eastern U. S. continues to grow rapidly. In Florida, where no local lightweight aggregates are available, high quality pumice aggregate is imported in bulk cargo quantities from Greece for use in building blocks. On the West Coast, the use of volcanic cinders as an aggregate was gaining in importance.

Canada in 1954 was showing progressive interest in **lightweight aggregates.** Bloated shale and clay aggregates were being produced in three western and two eastern plants. The Swedish-developed, cellular lightweight building material known as *Ytong,* produced from a mixture of lime, pulverized siliceous material and a chemical additive which is steam-cured in an autoclave, is now being manufactured by the Alberta Ytong Mfg. Co. of Calgary. Simporex, another similar lightweight building material also developed in Sweden, is to be produced early in 1955 at a plant of the Dominion Tar & Chemical Co.

SPECIAL SANDS & ABRASIVES—The demand for silica as a raw material in 1954 was generally good, but the market was strong for certain uses and weak for others. Quartz sand for consumption in the glass industry continued at the high level of the past few years. **Quartz** for special chemical purposes and for manufactured abrasives was in steady demand. Refractory quartz continued to find wider use, particularly where beneficiated raw materials were utilized to produce heavy-duty silica refractories. The increasing adoption of reclamation of foundry sands among the larger users cut into this market. The demand for sand of coarse grain-size, with a high degree of sphericity, is increasing from the petroleum industry for use in hydraulic fracturing of oil-bearing formations.

To meet ever-widening markets and overcome transportation costs, the **silica sand** industry has developed new facilities widely scattered over the country. This trend prompted resource studies of silica sand by the USGS, and some state geological surveys.

Beneficiation of **glass sand** is becoming increasingly important as producers are required to concentrate on a wider range of products and increase product quality. In demanding more rigid chemical and physical specifications, consumers have the advantage of a sharply competitive market.

Glass research laboratories continue to probe into unique properties of glass and silicon-bearing compounds, and applications of glass fibres grow in importance. Phenomenal growth of the fibre-glass reinforced plastics is predicted within the next five years, to cite one instance. The future for the industry appears to be that of healthy development.

In Arkansas, a drilling and sampling program was reported under way by the Geological Exploration Co. Inc. to evaluate sections of the diamond-bearing kimberlite pipe. Commercial quantities of garnet are being produced near Fernwood in Benewah County, Idaho. On Gore Mountain near North Creek, N. Y., the Barton Mines Co. is removing overburden along the strike of the deposit and opening new benches which substantially improve its ore reserves.

RARE MINERALS & METALS—In 1954, **selenium** had the dubious honor of being in the most critically short supply of all of the essential defense minerals of the U. S. Production of selenium metal, almost entirely as a byproduct from anode sludges in the electrolytic copper refining, exceeded 1 million lb in 1954, but fell well short of requirements. Over half of the production was converted into high purity stock for use in selenium rectifiers essential to military and civilian electronic developments. Extensive research aimed at developing new sources of supply was carried on by different groups, but no favorable results have been announced.

Uranium ores of the Colorado Plateau may be one potential source of byproduct selenium, but the lack of systematic selenium analyses of purchased ores by the AEC has hampered evaluation. The USBM, on behalf of the GSA, is currently investigating the grade, extent, and amenability to processing of several potential, low grade sources of selenium. Battelle Institute is continuing its research on the recovery of selenium from *astragalus* and other selenium indicator plants known to concentrate selenium during growth.

As the year ended, prices for commercial-grade selenium metal rose to $6 to $7.25 per lb, and a gray market in high-purity selenium existed. Rigid export controls were still in force. World market prices for selenium were well above those at home. Research on titanium, silicon, and other types of rectifiers was intensified by the shortage. Because of the unique physical and chemical properties of selenium, its uses are varied, and future demands for the metal are predicted to continue at a high level.

Refined **germanium** and germanium oxide were in abundant supply in 1954 as production developments from U. S. and African sources outstripped, for the present at least, demands of technologic applications on a production basis. However, Transistor Products Co., reported 1954 germanium transistor production up four times over 1953 and projected a threefold increase for 1955. Mass production of germanium transistors, begun by the General Electric in late 1954, is anticipated to grow into a $10 million business within three years. Intensive research continues on silicon transistors, superior to germanium in certain properties, but the cost of producing high-purity silicon places limitations on the scope of applications. Bell Telephone Laboratories are conducting interesting research in the field of solar batteries, employing silicon.

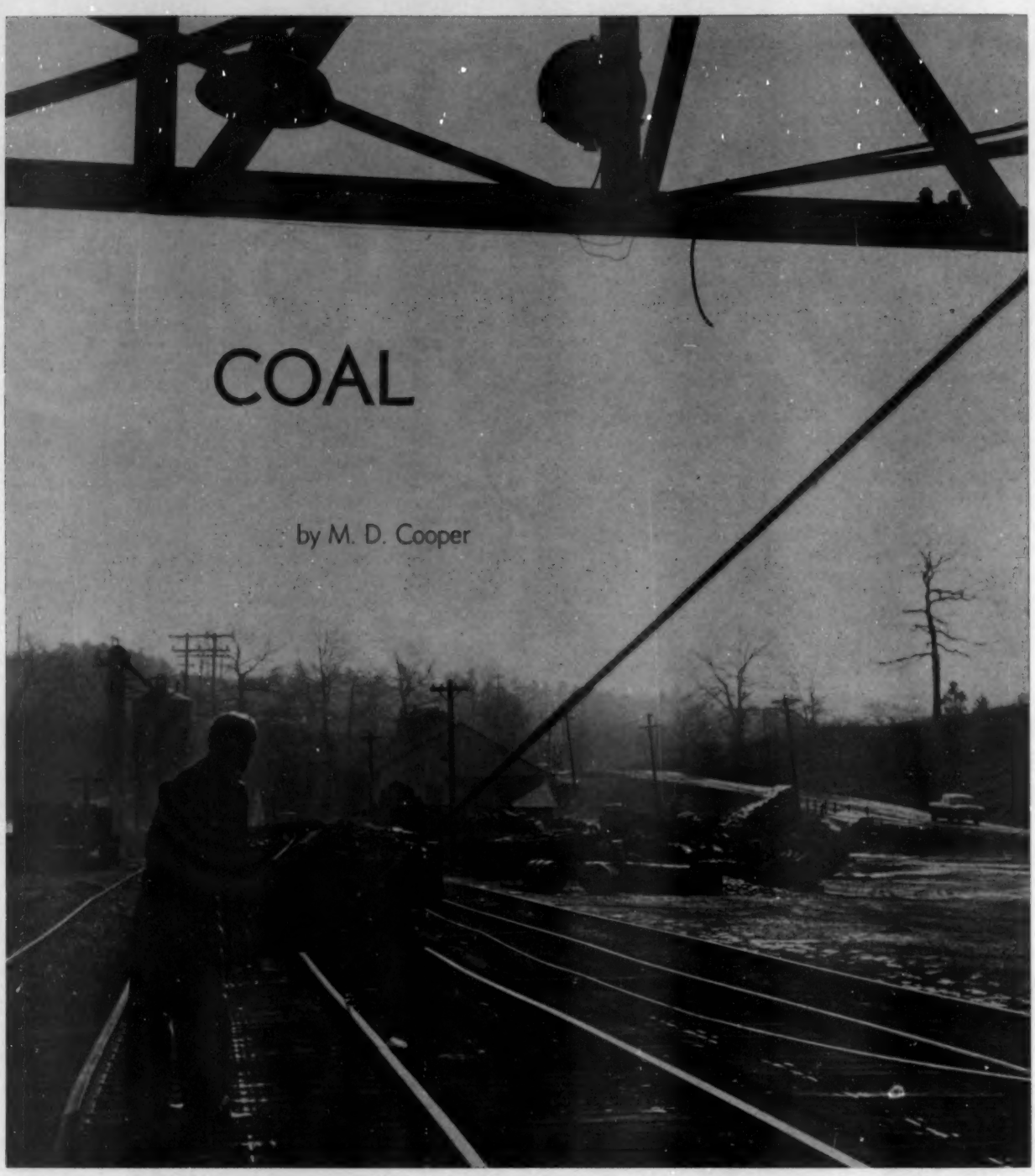
Zirconium metal and stabilized zirconium refractories production have ore supplies currently adequate to meet all requirements. Brush Development Co. produced the first ductile zirconium in 1954. Carborundum Metals Co. produced zirconium metal for commercial applications in addition to its AEC contract requirements. The USBM intensified research in the production of hafnium-free zirconium.

World production of **beryl** ore declined as prices dropped. Two new beryl properties in Georgia, explored with DMEA cooperation, have repaid the Government loan out of production royalties during the past year. Progress has been made in USBM research on beryl flotation, but difficult problems are still reported to exist.

Columbium-tantalum supplies remained high on the critical list of defense minerals, but 1954 production was up slightly over 1953. World market prices were more or less controlled by the 100 pct bonus price schedule offered by the Government, but it was more attractive to most producers to sell in the open market than to the U. S. stockpile, principally because of delays and uncertainty of bonus payments. It was reported that the Porter Bros. Corp. dredging operations 45 miles north of Boise, Idaho, would produce substantial quantities of columbium-tantalum along with monazite when operation begins in 1955. Boreal Rare Metals Ltd. produced and processed a small quantity of columbium-tantalum ore in Canada in 1954. A number of companies are actively engaged in columbium-tantalum and rare earth exploration and development in Canada. Geomines in Africa was reported to have completed the reworking of stockpiles containing columbium-tantalum-bearing material produced as a byproduct of tin production. Amalgamated Tin Mines of Nigeria Ltd. is reported recovering 5 to 6 tons of columbite per week in a pilot plant from a biotite granite in which the mineral occurs as an accessory. The deposit is unique in that it appears to have no relation to the usual hydrothermal or pegmatitic environment of columbite. Certain riebeckite granites in Nigeria are known to contain **pyrochlore**, essentially a sodium niobate, as an accessory mineral, and the deposits are currently being diamond-drilled. The pyrochlore is soft and brittle, however, so recovery may be difficult. New discoveries of pyrochlore were also reported in Tanganyika.

Much of the rare earth production is in the form of monazite, which is being exploited today for its **thorium** content. The largest domestic monazite operation is that of Baumhoff-Marshall Inc. in Idaho (MINING ENGINEERING, March 1945), with facilities for dredging and concentrating commercial monazite with byproduct zircon, ilmenite, magnetite, and garnet. The titanium dredging operation at Aiken, S. C., will yield monazite as a byproduct (see titanium). Peculiar intrusive plugs of carbonatites in Uganda and Kenya contain rare earth minerals and phosphates. Residual deposits enriched by leaching of carbonates are reported under development as a source of pyrochlore and apatite. The Molybdenum Corp. was employing a dry roasting of its California bastnaesite ore, a fluocarbonate of cerium metals, to yield a 95 pct rare earth oxide product. The price of this corporation's product was reduced 50¢ per lb during 1954. Research and furnace trials indicate rare earth oxides can be added directly to steel melts in place of metallic rare earths as misch metal. Canned oxides can be submerged into the melt to achieve a better mixture throughout the bath according to some authorities. It remains to be seen how widely this practice will be adopted in the steel industry. In an AEC-sponsored project, Battelle Memorial Institute developed a new process for recovery of thorium and the rare earth metals from monazite, utilizing a sodium hydroxide leach followed by treatment with hydrochloric acid to permit early removal of phosphates.

Kennecott Copper Corp. is reported to be developing production of **rhenium,** a rare metal found particularly in association with certain molybdenum ores. Its principal use is in the manufacture of thermocouples. **Scandium,** a rare metal occurring with certain rare earth and pegmatitic minerals, was reported to be attracting attention of research workers.



COAL

by M. D. Cooper

PRODUCTION of both anthracite and bituminous coal in 1954 was about 16 pct below 1953. Estimates on Dec. 1, 1954, indicated 27 million tons of anthracite and 385 million tons of bituminous.

Decline in production was due principally to lower demand by the steel industry and the railroads, although competition from other fuels also affected coal. The year was notable for vigorous effort by the coal industry to promote the use of its product. A Cabinet Committee on Energy Supplies and Resources Policy and an Interdepartmental Committee on the Soft Coal Industry were set up by the Administration in Washington. A Governors' Fuel Conference was also organized.

Great emphasis was placed on the reduction of accidents due to falls of roof, face, and sides. The Pennsylvania Dept. of Mines reported in its *Safety Sentinel* for February 1954 that 885 linear miles of roof in entries and rooms had been bolted in the state's bituminous mines. No serious or fatal roof fall accidents had occurred under those 885 miles. By October 1954, 1380 miles had been bolted, with the same accident-free record.

In cooperation with the colleges and universities offering courses in mining engineering, the National Coal Assn. promoted training leading to employment in the industry. Teachers and students in secondary schools were provided with information about the industry and studies required for admission to engineering courses. In 1953 and 1954 the American Coal Sales Assn. sponsored intensive sales courses at Purdue and Pennsylvania State University.

M. D. COOPER, National Coal Assn., Pittsburgh, was 1954 AIME Coal Div. Chairman.

Mining

by M. H. Forester

For the first time since 1939 bituminous coal production dropped below 400 million tons. Inroads of natural gas and fuel oil into the domestic railroad fuel and steam markets were primarily responsible, but steel industry operation at 70 pct or less contributed to the loss. Marginal and high-cost mines ceased operating in nearly all mining regions, some temporarily, some permanently. Few commercial operators remained unaffected. Since realization was considerably below the 1953 average, activity in 1954 was dominated by the urge to make every possible cost reduction.

Mining equipment purchases were below 1953 levels, even though the trend to off-track mining continued. Use of shortwall cutting machines and shaking conveyors has been largely discontinued. While main line locomotives are still in limited demand, gathering locomotive purchases have practically ceased.

Demand for belt and chain conveyors dropped 40 to 50 pct from 1953. The bridge conveyor, developed primarily for low vein mining with chain conveyors and loading machines, appeared to be gaining acceptance even in high coal as an important aid in reducing production time losses due to inadequate face transport. A new type of surge car employing the bridge-conveyor principle is undergoing tests.

Search continued for an economical fire-proof belt material suitable for underground use. Although confined chiefly to surface plants, trial installations of stainless steel belts increased.

Loading machines of the off-track type continued to replace hand loading as well as those machines not suitable for conversion. Shuttle car sales merely kept pace with 1953, affected, no doubt, by the availability of equipment from idle and abandoned mines. The unwarranted resistance to the use of diesel shuttle cars underground continued.

Continuous mining machines of five different types were installed in both high and low coal mines during the year, bringing the total of such equipment to about 315 units with an estimated production of 14 million tons, an increase of more than 20 pct over 1953. Use of extensible belts for face transportation provided continuity of operation and greater productivity. Yields of more than 100 tons per man day, and advances of more than 100 lineal ft per hr, have been achieved in 6-ft coal. Experience with foreign equipment on longwall faces during 1953 was sufficiently encouraging to justify additional purchases for low coal recovery in 1954.

Along highways operation of production units with remote controls was developed further but has not yet been adapted to underground use. A new type of auger intended for use on pillar recovery has been designed and built but not yet tested.

Roof bolting, easily adapted to a variety of roof conditions, is entrenched in all mining regions. Roof control costs have been reduced, efficiencies increased along several lines, and safety factors materially improved. It has been estimated that there were 20 anthracite and 433 bituminous coal mines using roof bolts on Dec. 31, 1954, with 109 bituminous mines deriving 100 pct production from bolted areas.

In an effort to eliminate the major cause of underground fatalities, the U. S. Bureau of Mines, state mining departments, and management research groups started concentrating on basic roof control at the face.

During the past year members of the mining development program of Bituminous Coal Research Inc. investigated the effect of factory-type illumination on underground production. In two West Virginia mines demonstration units were installed. Both area illumination and face lighting are being developed in a practical and economic way.

There is every reason to believe that investment during 1954, leading to still greater mechanization and modernization, will be reflected in greater financial stability. Increasing demand for coal during the last quarter of 1954 suggests an upward trend in volume and productivity during 1955.

Preparation

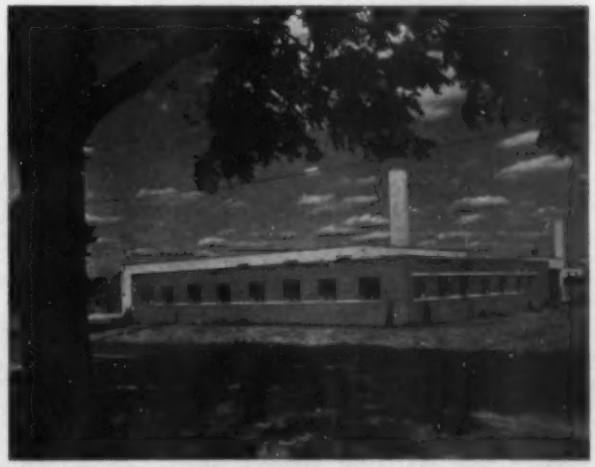
by J. A. Bottomley

Improvements in filters, cyclones, and wet and dry dust collectors contributed to the handling of extreme fines. Screening and centrifuging were of continued importance in the handling of coarser fractions of fine coal. Demand for closer control of the bottom size of premium stoker coals called for improved screening and dewatering, although this meant attendant difficulties and drying costs. Engineers and manufacturers are striving to lessen the amount of extreme fines due to crushing. Installation of washing tables continued at a rapid rate to provide added recovery of fine fractions.

As a result of cost analyses, rewash cleaning equipment received increasing consideration in many of the older plants. For many operations recovery of a few tons of coal now wasted in refuse or slurry pond could well be the difference between survival or failure.

To lower costs of handling refuse, pumping was incorporated in both old and new plants. There has been considerable experimentation as to the optimum size. Research efforts to avoid or minimize air and stream pollution continues to be an important phase of coal preparation.

Increased emphasis on design to reduce operating manpower was evident during 1954. Complete automatic lubrication was included in the original design of some new installations and was incorporated in many old plants. Control centers were designed



This is the laboratory of Bituminous Coal Research Inc. at Columbus, Ohio, where new and better ways for using coal are constantly being sought.

to eliminate manpower requirements. Multiple units to lessen down time are becoming a must in many cases. Alloys and synthetics are of even greater importance in new construction and in replacements in old plants.

The year 1954 has further emphasized the importance of the preparation engineer. New and better products to gain markets are planned in his department, while the problem of added recovery is ever before him. He maintains the contact between operating and sales departments, and in working on the problem of air and stream pollution he has a definite influence on public relations.

Utilization

by Carroll F. Hardy

The first big plant to use steam at supercritical pressures was announced by the American Gas & Electric Corp. in 1953. The second, announced in 1954, is to have a 125,000-kw capacity and will operate at 4500 psig at 1150°F with two-stage reheat. It is expected to have a net heat rate approaching 8500 Btu per kw-hr with an overall efficiency of around 40.3 pct.

Philadelphia Electric plans to build a 275,000-kw turbine generator supplied by a single boiler. Steam pressure will be 5000 psi, and steam temperature will ultimately be 1200°F. At 1150°F the expected heat rate is 8400 Btu per kw, some 600 Btu per kw lower than the heat rate of the most efficient existing station. Overall efficiency is expected to be 40.6 pct as compared to the present 37 pct.

Coal-burning utility plants in 1954 established a record in coal utilization; for the first time the coal rate of all coal-fired steam plants in the U. S. dropped below 1 lb per kw-hr for a month. It is probable that the rate for the entire year will be 1 lb or slightly over.

Industrial customers have shown increased interest in the cyclone furnace, which burns —⅜-in. top size coal in suspension without pulverization.

The breaking of ground for the prototype atomic energy generating station at Shippingport, Pa., led many coal men to wonder what effect competition from atomic energy would have on the coal industry. In spite of the usual rash imaginative statements that seem always to accompany a new development, significant quantities of dependable electric power from atom-powered plants are still many years in the future.

The phenomenal growth in electric generation, at conservative estimates, will continue at the rate of around 6½ pct per year in the foreseeable future. The tonnage of coal sold to this utility market will continue to increase, even though sales will be slowed by the increase in utilization efficiency.

The trend towards physical mergers of coal producing and selling companies has continued in 1954. This, in the main, has tended toward better and more orderly marketing. As a result of improper purchasing and selling policies, the coal industry is operating at a loss. Better marketing, that is, selling coal at a profit, is essential to maintain the present excellent physical plant of the industry.

Research

by Harold J. Rose

Bituminous coals are being studied to determine bright coal, dull coal, and fusain contents and their free-swelling properties. The relation between rank and composition and other geological factors is being examined. Petrographic composition and the chemical reactivity of bituminous coals are being investigated and plasticity studies made on various coals and coal mixtures. Infrared techniques are being utilized in the study of coal and related substances.

The Elrama power station of Duquesne Light & Power Co. Coal-burning utility plants established a record for utilization of Coal in 1954.

Utilization as a Fuel: Last year saw the dedication of the first coal research association laboratory. Projects such as the development of package-type automatic steam generators for commercial and small industrial plants and projects for development and testing of agricultural and residential equipment are being conducted in the Bituminous Coal Research Inc. Laboratory. The locomotive development program continues tests with a coal-fired locomotive-size gas turbine.

Private companies and universities are conducting combustion research on stokers and stoker coals. Norfolk & Western Ry Co. has developed and road tested a coal-burning steam-turbine electric locomotive.

Conversion: Low-temperature carbonization of coal leading toward the production of chemicals and synthesis liquid fuels has been continued by several companies.

An improved electrically heated test coke oven has been developed for coke quality control and the effect of weathering on coke quality has been studied. At the Institute of Gas Technology a process has been developed for the pressure gasification of coal in suspension without coke, tar, or other by-products.

Summary

Owing to the efforts of those engaged in the industry and governmental agencies, production apparently will increase, and 1955 will show at least a reasonable gain. Safety and educational efforts were carried on at an accelerated pace. Mining operations continued to introduce new machines, and the use of conveyor belts was extended. Capital investment in mechanization indicated increasing financial stability and faith in the future.

Progress made in 1954 indicates that the future of coal is secure for years to come. The temporary slump in production resulted in no general feeling of depression but seemed rather to spur the industry to greater effort to insure its own future.

Annual Review

Mineral Industry Health & Safety

by S. H. Ash

SAFETY records in the mineral industry for 1954 will do well to hold their own as compared with 1953, because of the poorer rate in the coal-mining branches, even without the recent mine explosion at the No. 9 mine of the Jamison Coal & Coke Co., Farmington, W. Va., that killed 16 persons. The cause of that disaster has not yet been ascertained. The metal-mining branch appears to have improved its record over the last year, however.

Health

Diesel equipment continues to be favored in noncoal mines. Equipment includes locomotives, trucks, tractors, and muckers. Of major concern and interest is the establishment of a new threshold limit for oxides of nitrogen—5 ppm as compared with 25 ppm. This gas is the most harmful component of diesel-engine exhaust gas.

A lower limit was recognized as inevitable by the author and the New York Dept. of Labor in 1940 when a schedule was established for the use of diesels underground. At that time, to control oxides of nitrogen in the general air, a limit of 10 to 20 ppm of carbon monoxide was adopted by New York and has been used as a guide by other metal-mining states. The limit of 5 ppm is not difficult to attain with normal ventilation if there is enough fresh air to keep the CO within the aforementioned range. Enough ventilation is obtained under normal conditions with indirect-injection, 4-cycle engines.

The first requisite for preventing dust disease is to avoid exposure to harmful dusts. Experience is the greatest teacher, and its lesson is that it is "better to be sure than sorry." For this and reasons of economy, industry today is giving wider recognition to the fact that proper dust control and enough ventilation are assets.

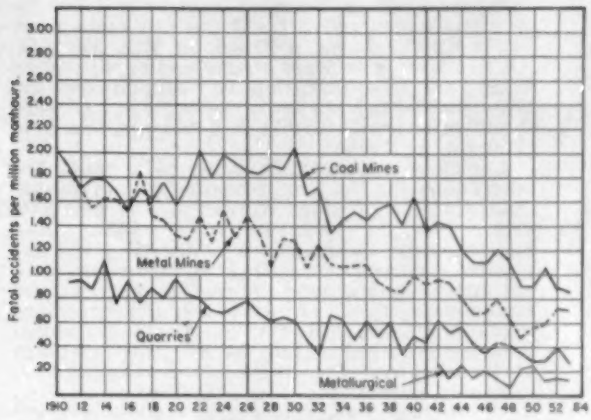
Control of Falls of Ground

Control of the roof, back, floor, and walls will prevent accidents from falls of ground that account for most mine accidents. The rate for such injuries is higher in coal mines than in metal mines—not because the roof or wall rock is any worse but because control measures are less effective.

Rock bolting continues to be the most outstanding procedure that is reducing the injury rate in mines by preventing accidents from falls of ground. Pure logic and statistics never won popular support for any cause in any group. Nevertheless, statistics do provide a yardstick by which progress can be measured, as shown by the table.

The noncoal branch of the mineral industry recognizes that the worker is the key man in preventing rock-fall injuries, for without his effort in that direction little or no improvement can result. The most recent concerted effort in the right direction has been started by a national campaign.

S. H. ASH is Chief, Safety Branch, Health & Safety Div., USBM, Washington, D. C.



Fatal Injury Rates Since 1910

Bituminous Coal, Underground Mines

Production per month of all mines, million tons	34.4
Bituminous production actually mined under bolts, pct	25.8
Fatal injuries from falls of roof	215
Total fatal injuries for fiscal year	370
Roof fall fatalities in localities where bolts were in use	13
Fatal roof fall accidents per million tons mined under bolts	0.257
Fatal roof fall accidents per million tons where timbers alone were used for support	1.33

Using these figures, at least 54 men are alive who would have been killed were it not for roof bolting. If roof bolting were in 100 pct use, projected figures indicate only 52 roof fall fatalities would have occurred, not 215.

Training

Visual training has proved to be of great assistance in instructing supervisors and workmen in standard practices, changes in procedures, and interchange of ideas. Such training is simpler and easier to understand than written or oral methods and proves particularly applicable in large operations with several producing mines.

The most recent and positive practice in some places is personal-contact instruction given regularly by each shift boss to all men under his supervision. An individual record is maintained of all personal-contact instruction received by each man.

Research

Developments are noted in removing the hazards of noise, to substitute fluorescent lighting for individual lighting in mechanized operations, to prevent fires at conveyor installations, and utilize more controlled blasting practices.

Operational planning and research have resulted in the adoption of many types of safety protective equipment. Some of this protective equipment has been selected after accidents have occurred; however, much of it is the result of careful foresight before introducing new methods or processes.

The use of Scotch-lite signs has increased, as indicators of direction, to caution or warn, and for many other purposes. Signs can be produced locally, and many novel uses have originated at the plant.

During the past year the U. S. Bureau of Mines completed considerable research and has in process of completion the Information Circular, *Some Information on the Performance of Diesel Exhaust-Gas Scrubbers.*

Disasters

Up to Dec. 15, 1954, two major disasters struck the mining industry—one in a bituminous coal mine and one in an open pit metal mine. Both disasters were preventable.

A premature explosion of 15 cases of dynamite on a truck occurred at the Santa Rita open pit in Santa Rita, Ariz., at 4:00 am on Mar. 31, 1954. All five men, who were at the loading site, were killed, so no explanation is available for the pieces of leg wire from a detonator that were found attached to the broken blasting machine after the explosion.

A violent explosion followed by a mine fire occurred at the No. 9 mine of the Jamison Coal & Coke Co., Farmington, W. Va., at 1:45 pm, Saturday, Nov. 13, 1954. One man working in a building near the manshaft at the time the explosion occurred was killed, and 15 men were entrapped underground. A raging mine fire and high concentrations of methane and carbon monoxide precluded recovery of the 15 entrapped men and required sealing the five mine openings at the surface. The cause of the explosion is unknown at this time (Dec. 15, 1954).

Fatal-Injury Rates

Actuaries have found in mining experience that accident-rate trends form high peaks and low valleys over approximately five-year periods; 1953 had the lowest fatal-injury rate in the history of mining (0.59 per million man-hr); this is also true of the quarrying branch, when a rate of 0.26 per million man-hr was reached. The combination of quarries and metallurgical plants aids much in reducing the overall rate for the mineral industry, and their methods of accident prevention could well be studied by the other branches of the industry.

The general downward trend of fatal-injury rates, particularly during the last 30 years, is a good criterion that lower injury rates can be expected. To make this possible, *safety must be made an integral and essential part of each operation rather than be considered as separate and apart.*

Safety Is Everybody's Business—management, industrial relations, supervisors, workmen—all working together. It is only through the sincere cooperation of all concerned that important improvements in safety conditions and accident experience have been made.

National Safety Campaign

The Mining Section of the National Safety Council is conducting a campaign for preventing accidents due to falls of ground—by far the biggest safety problem in the mining industry. All noncoal mines in the U. S. and Canada employing 25 or more persons in the underground force may participate, whether or not the company is a member of the Mining Section of the National Safety Council.

Objective—The goal is a reduction of 50 pct in falls-of-ground accidents—an accident being, briefly, one that causes an injury resulting in loss of time from work or requiring the attention of a doctor. The program is so designed that each mine will compete against its own record and performance will be judged on improvement.

Sponsor—The campaign is sponsored by the Mining Section of the National Safety Council. Endorsing and cooperating in the campaign are Governmental mining agencies, mining associations, mining publications, and others having an interest in the welfare of the mining industry.

Duration of the Campaign—The campaign began Jan. 1, and terminates Dec. 31, 1955.

Eligibility for Participation—Any underground mine, excluding coal, may participate in the campaign, provided 25 or more employees work underground. Membership in the Mining Section of the National Safety Council is not required. Nonmember companies may obtain materials for conducting the campaign at member prices instead of the usual charge of twice the cost to members. Mining companies outside the boundaries of the U. S. are invited to participate.

Requirements for Participation—

a) If a company operates two or more mines, each mine must be enrolled separately.

b) Each participant agrees to furnish a simple report of injuries resulting from falls of rock and ore for the year, or two or three years previous to 1955, depending on the period for which records are available; a report at the end of the first six months of the campaign; and a report covering the last six months.

Campaign Materials and Activities—The National Safety Council will make available various materials to enable participants to carry on a continuous and effective campaign:

Posters—A special series of 12 posters, one for each month of the campaign, may be obtained.

Falls-of-Ground Accident-Prevention Booklets—There will be four small, illustrated booklets in two colors, each containing eight or nine important facts about falling-ground accidents and major safety measures for preventing them, for distribution to employees at intervals of three months.

Visual Aids—A sound slide-film, *Falling Ground* produced by the Anaconda Copper Mining Co., and *Bar It Down*, available in 35-mm. color film and 2x2 color slides, with a Leader's Guide, produced by the Mining Section of the National Safety Council, and a safety-graph dealing with falling rock, *It Can Happen to You*, produced by the Mining Section of the National Safety Council, will be available for showing at safety meetings.

Banners—A banner for reminding employees about the hazard of falling ground and for publicizing the campaign will be available for use at the mine.

Publications—Publications, such as data sheets and information sheets, will be supplied for reference in discussing various aspects of preventing falls-of-ground accidents at supervisory and employee safety meetings.

Safety Stunts—A choice of several suggested safety stunts for creating and maintaining interest in the campaign will be provided.

Campaign Plan—Each participant will be furnished with a suggested plan for systematically using the materials and carrying on the various activities throughout the campaign period. Each participant may select the materials and activities most suitable for its facilities and needs and schedule them during the campaign as needed.

Recognition for Good Results—The National Safety Council will award a Certificate of Achievement to all mines for:

a) A reduction of 50 pct in the frequency of injuries from falls of ground (as specified on the report form) in comparison with the record for the previous period reported by the mine.

b) Or going through the campaign year without a chargeable injury due to a fall of ground as defined on the report form.

Refractory Design Increases Rotary Kiln Efficiency

by W. F. Rochow and W. C. Burke

Numerous designs of linings and accessories, including dams, lifters, and heat exchangers, contribute greatly to kiln efficiencies. Greater conductivity is achieved with basic brick than with fireclay and high-alumina refractories, depending largely upon the use of steel plates in radial joints between adjacent brick to increase heat transfer through the lining. Refractory lifters expose all portions of the load to radiant or convective heat and raise some portions to higher temperatures by cascading the load down through the path of the hot gases.

AMONG the many factors involved in rotary kiln efficiency, advantageous use of refractories is of major importance. So far as kiln lining alone is concerned durability is most significant, as shutdowns for repairs are costly in fuel consumption and production losses. Aside from selection of refractories best suited to the widely varying conditions under which rotary kilns are operated, lining design and accessory constructions within the kiln are highly important.

The refractory most economical for any combination of operating conditions can be selected from a wide range of alumina-silica and basic refractories, including insulating, castable, and plastic fire bricks. In several cases silica brick can be used to advantage.

Alumina contents of alumina-silica refractories range from 35 to 90 pct in increments of 5 to 10 pct. In general, bricks of relatively low alumina content are best for abrasion resistance, an important property for the brick used in chain sections of cement kilns or in feed end sections of limestone kilns. High-duty fireclay bricks of approximately 40 pct alumina and 55 pct silica are used to line the intermediate zones. Super-duty fireclay brick at slightly higher cost is warranted in operation of kilns with high intermediate zone temperatures and severe spalling conditions.

Alumina-silica refractories with an alumina content of 50 pct and higher, termed *high-alumina* brick, are available in commercial classes of 50, 60, 70, 80, 85, and 90 pct alumina content. These refractories are generally used as high temperature zone linings or placed adjacent to the basic brick-lined sections when the treatment they are required to withstand is excessively severe.

Use of basic refractories is confined mainly to zones of maximum temperature and most severe chemical action. Basic refractories ordinarily employed for high temperature zone linings of many rotary kilns comprise the classes shown in Table I. Each class is peculiarly well suited to various particular combinations of working conditions.

The approximate chemical analyses of these classes also illustrate differences in compositions with respect to the major components.

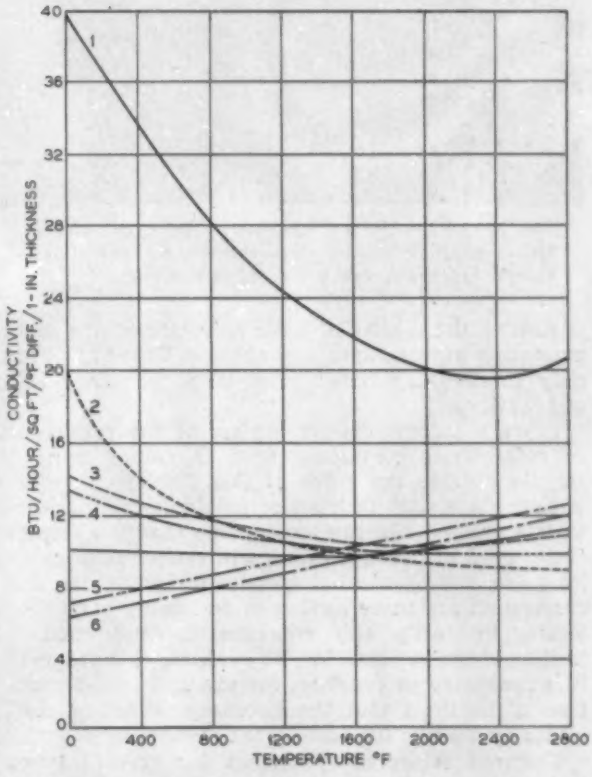


Fig. 1—Approximate thermal conductivity curves. 1—Hard-fired magnesite. 2—Chemically bonded magnesite-chrome. 3—Magnesium silicate. 4—70 pct Al_2O_3. 5—60 pct Al_2O_3. 5—Super-duty fire clay. 6—High-duty fire clay.

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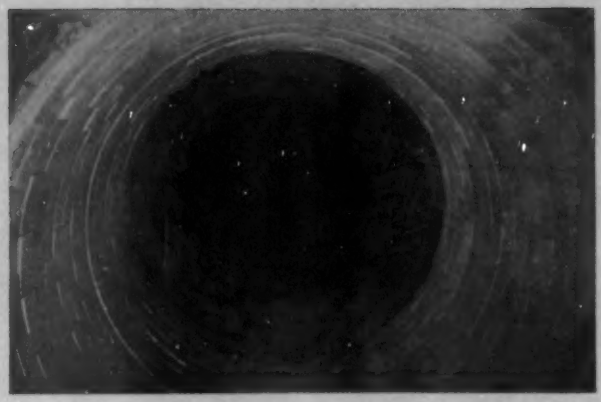
The Transactions papers appearing in Mining Engineering during 1955 will subsequently appear in AIME Transactions Vol. 202 and may be permanently referenced to that volume.



Figs. 2a and 2b—Lining of kiln interiors before and after a typical accretion build-up which obstructs the flow of the charge. Appreciable cost is involved in removal.

Among the classes of basic refractories are those consisting predominantly of chrome. There has been only limited experience with these in rotary kiln applications.

Since a comprehensive review of the properties of refractories commonly used in rotary kilns is largely outside the scope of this discussion, reference is made only to those of particular significance to this subject. On the assumption that the refractories used in the kiln lining will render reasonably long life, the physical properties of interest in this connection are those having to do mainly with heat losses. Primarily this concerns thermal conductivities of the refractories. To evaluate this property it is necessary to consider, for example, the formation of coatings and the necessity of using steel plates or casings for basic brick installations.

Thermal conductivity curves for several types and classes of refractories commonly used in rotary kiln linings are shown in Fig. 1.

In the burning of lime, in several instances, magnesite brick and periclase brick are used beyond the burning zone limits solely for the purpose of securing the maximum degree of purity of lime for exacting chemical requirements.

As illustrated by the curves, Fig. 1, basic brick refractories have higher conductivities than do the fireclay and high-alumina refractories. Moreover, the successful performance of basic liners is largely dependent upon the use of steel plates in the radial joints between adjacent brick. This practice increases the transfer of heat through the lining. Despite these facts, it has been determined by experience at many rotary kiln plants that linings 6 in. thick serve more economically than those 9 in. thick, which of course cost proportionately more. This may be explained by the fact that a coating forms on the lining. With basic refractory linings especially, such coatings are exceedingly desirable, even though appreciable cost is involved in removal when they become excessively thick or when large

Table I. Approximate Chemical Analyses of Refractories, Pct

Class	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3
Chemically bonded magnesite-chrome	4.5	15.1	7.7	1.8	52.0	15.3
Hard-fired magnesite-chrome	4.7	15.5	8.7	15.7	53.4	15.7
Hard-fired magnesite-chrome (natural calcium silicate bond)	8.2	4.1	6.7	19.0	56.0	6.2
Hard-fired magnesite-chrome (MgO-Al_2O_3 spinel bond)	4.5	21.6	6.4	1.8	52.1	13.8
Hard-fired magnesite	4.8	1.0	1.8	3.3	89.1	0.0
Hard-fired periclase	5.6	0.3	0.6	0.9	92.6	0.0
Hard-fired magnesium silicate (forsterite)	32.5	1.5	9.1	1.4	53.4	1.4

rings develop. The coatings provide valuable insulation and protect the lining against severe destructive conditions. Interruptions in operation for refractory maintenance most frequently are necessitated by the consumption of the high temperature zone linings. It is in this zone that the coatings, when not excessive, are most desirable. Often special procedures and practices are followed to cause the kiln product to adhere to the lining and build up to an optimum thickness. In the high temperature treatment of refractory dolomite and magnesite for dead burning a small amount of iron oxide added to the charge helps promote a satisfactory coating. In some cases preheating the lining close to the operating temperature before introducing the charge has helped to accomplish the same results.

Formation of coatings may be caused by various phenomena. When not of such severity as to result in a fluid slag, chemical reaction between the charge and the lining can promote an accretion accumulation. Coatings can also be formed without appreciable fluxing of the lining, as in the clinker of certain mixes and the sintering of iron ore. In lime kilns the ash of pulverized coal used for fuel often accounts for development of the coatings and rings in the burning zones.

Conversely, under some circumstances, disadvantages far outweigh the benefits derived from

Fig. 3—An example of desirable coating, which provides valuable insulation and protects the lining.

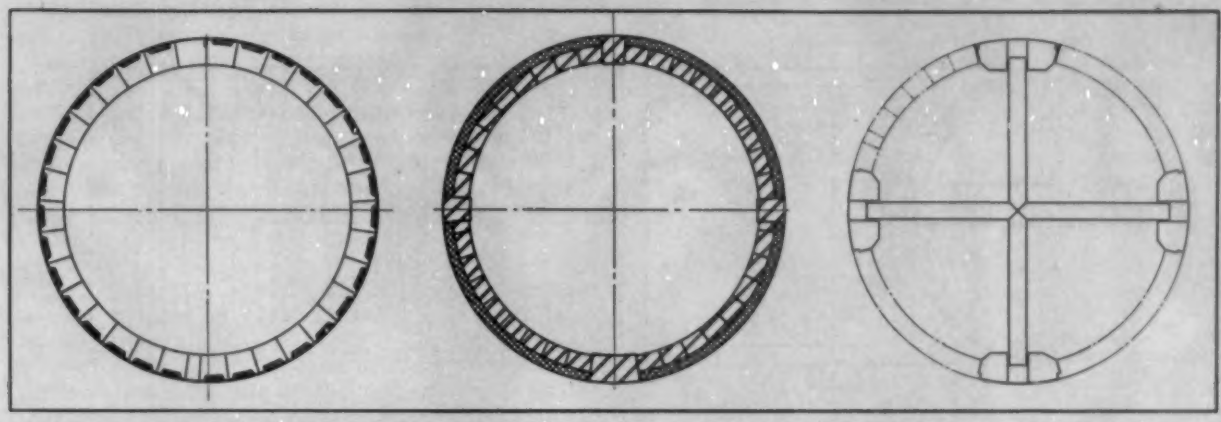


Fig. 4 (left)—Refractory radial blocks provided with a recess for insertion of insulating material. Fig. 5 (center)—A design offering more complete insulation. Fig. 6 (right)—An example of right-angle cross tile construction.

coatings. Serious interruptions may be necessary for their removal. The coatings and rings can become of such magnitude that the kiln must be shut down, with resulting loss of production time.

Figs. 2a and 2b are pictures of kiln interiors showing the lining before and after a typical accretion build-up which obstructs the flow of the charge to the extent of necessitating a shutdown. Fig. 3 is an example of a desirable coating.

Special kiln designs, boring machines, carbon dioxide bombs, various types of guns, and carefully controlled operations help reduce the difficulty to a reasonable minimum.

Insulation: At several plants it has been the practice to insulate basic refractory linings with fireclay brick because of the difficulty experienced in building and maintaining coatings. Without a substantial coating or adequate insulation the shell became overheated, owing to the relatively high conductivity of the basic brick. A 3-in. thick course of radial fireclay bricks laid in a close fit against the shell provides the insulation. Upon this is superimposed a 6-in. magnesite brick lining with 16-gage steel sheets in the radial joints. Insulating fire bricks are not used because they are not strong enough to resist the abrasion resulting from any movement of the refractory linings.

Except perhaps in a few unusual cases, insulation of the high temperature zones of rotary kilns holds little promise of success. On the other hand, many kiln linings are insulated beyond the burning zones with measurable savings. The waste heat from rotary kilns sometimes is utilized for steam generation and other purposes and the economies resulting from insulation of the kiln lining can be determined with some degree of accuracy. In the case of kilns operated with concurrent feed and fuel input, especially when endorthermic reactions are involved, there can be little doubt about the value of insulation. However, the operation of kilns with insulated linings must be controlled closely to benefit fuel efficiency and production rate and to avoid merely increasing the stack temperature.

Block insulation has been used extensively for kiln lining in applications where the interface temperature is not high enough to cause shrinkage of the insulation. Successful use of this material is based on its slight compressibility and its capacity to withstand the pressure imposed upon it. In most cases rigid insulating fire bricks placed between the kiln shell and the refractory lining have had to be replaced prematurely. While insulating bricks of this type are relatively strong, they are abraded excessively by movement of the hard refractory lining with which they are in contact. When this happens the refractory bricks become loose and ultimately fall out. However, prefired diatomaceous earth insulating brick produced abroad has been regarded as suitable for this application, mainly at cement plants in Europe and Canada. Although it is strong, it is not friable, and when subjected to pressure and abrasive action, the surface in contact with the hard refractory brick tends to compress slightly rather than to abrade away.

Table II presents temperature gradients and heat losses based on thermal conductivity data and calculated in accordance with the empirical formula commonly used. The temperature of 2200°F at the hot face was used in the calculations, as it was considered most representative of a wide range of operations.

In recent years, at a number of cement plants, insulating fire bricks have been used for the lining proper in kiln sections beyond the burning zones. They have been in service for several years, and there is every indication that they can be expected to last much longer. These linings are directly ex-

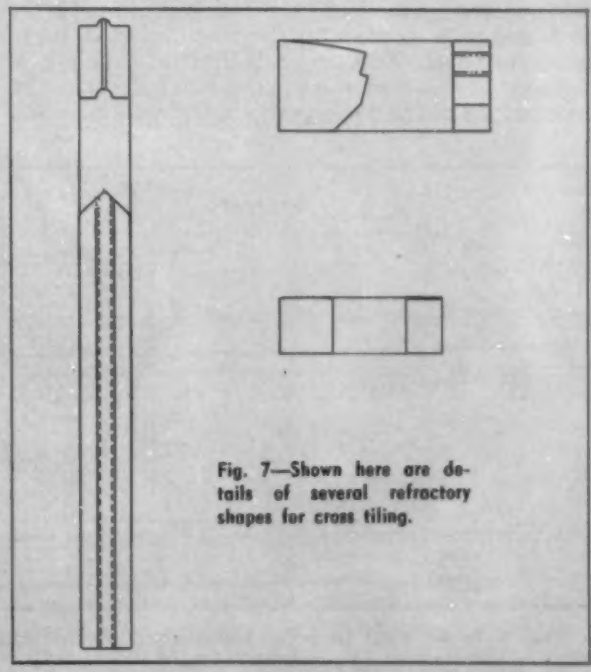


Fig. 7—Shown here are details of several refractory shapes for cross tiling.

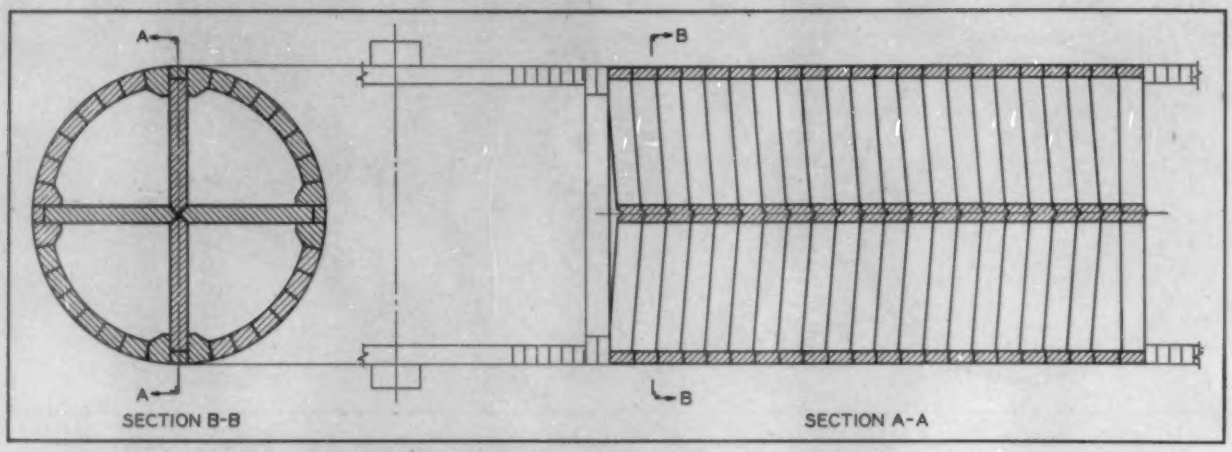


Fig. 8—This construction, which provides greater stability against forward thrust, is now being tried in two kilns, one for calcining refractory clays and the other for hard-firing dolomites.

Table II. Calculated Temperature Gradients and Heat Losses. Hot Face at 2200°F

Refractory	Temperature Gradient, °F	Heat Loss, Btu Per Sq Ft Per Hr
6-in., high duty, with 2½-in. block insulation	200	560
9-in., high-duty, with 2½-in. block insulation	270	500
6-in., high-duty	575	2400
9-in., high-duty	490	1680
4½-in., lightweight, high-duty	300	1035
9-in., high-duty	575	2400
4½-in. insulating brick	495	1720
6-in., high-duty	400	1080

Table III. Comparison of Physical Properties of Firebrick

Properties	High-duty	Light-weight, High-duty	2600°F Class Insulating
Weight, lb per cu ft	130 to 140	60 to 65	45 to 50
Modulus of rupture, psi	1000 to 1500	500 to 700	140 to 230
Cold crushing strength, psi	2000 to 3500	700 to 1000	150 to 250
Pyrometric cone equivalents	32 to 32½	700 to 1000	150 to 250

posed to the mix flowing over them. The fine dust has only a negligible abrasive effect and the bricks are strong enough to withstand pressures to which they are subjected. The important physical properties of light-weight fire brick suitable for linings as compared with those of dense fireclay brick are illustrated by the data in Table III.

Several trial installations on a relatively small scale have been made with refractory radial blocks provided with a recess for the insertion of an insulating material. This design is illustrated in Fig. 4. A lining of this kind is a compromise and cannot be as effective as the more nearly complete insulation, of which Fig. 5 is a typical construction. However, under certain circumstances there may be merit in using insulated rotary kiln blocks with the cutout because of the greater stability of the lining, Fig. 6.

Accessory Refractory Constructions as Factors of Efficiency: As governed by the functions and various operating factors, kiln efficiencies are greatly benefited by the use of chains (with wet charges), preheaters, metallic lifters, and other devices. Use of equipment made of metals is limited to relatively low temperatures.

To accomplish the desired reactions in rotary kilns most effectively, it is necessary that the charge be brought into intimate contact with the hot gases and with the radiated heat from the refractory linings and other brickwork within the kilns. In general the accessory constructions can be regarded as baffles of one type or another. Various designs of lifters, dams, and pocket arrangements are used.

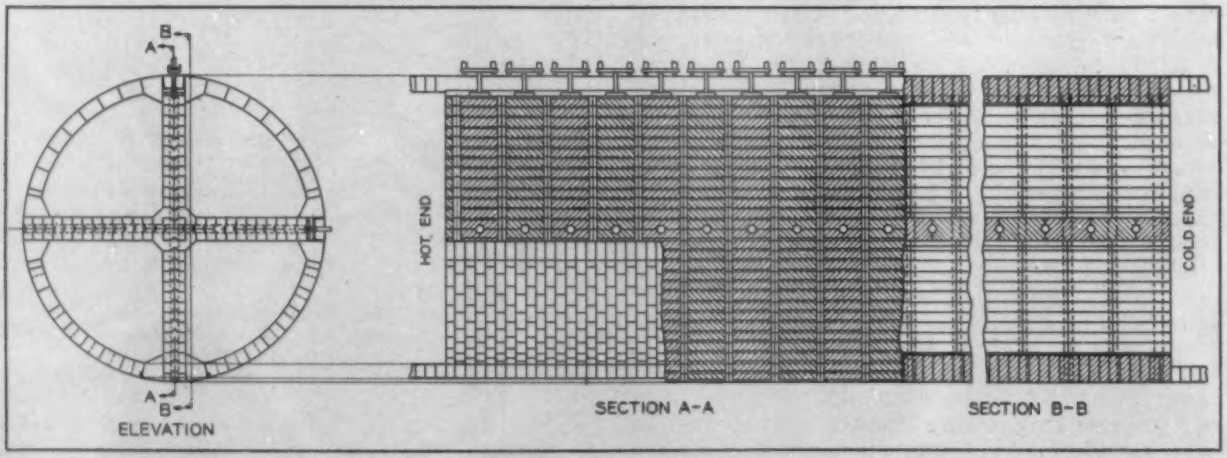


Fig. 9—In this design for a high-duty refractory smaller shapes are used than in the construction shown in Fig. 8. Tiles are provided with tongues and grooves bonded together by overlapping joints. Heat-resisting tubes are used for reinforcement.

Quadrant Dividers: Over the past 10 years there has been considerable experience with a right-angle cross tile construction, now in use in about 30 rotary kilns. At a number of plants various designs were installed in different locations in kilns of 8, 9, and 9½ ft diam. Figs. 6 and 7 are drawings of two designs of these cross tiles; Fig. 7 shows the details of several refractory shapes used.

These large quadrant tiles are made in lengths up to 4½ ft in the high-duty fireclay class of refractories, which has given longest service of the several classes tried. Up to the present this arrangement has been used only in limestone, dolomite, and marine shell calcining kilns. It is obvious that successful application will be limited by kiln diameter. The maximum for this dimension remains to be determined. Maintenance costs have been particularly high in kilns of largest diameters. A design which may prove to be better than others with respect to frequency and magnitude of repairs has the advantage of better stability against the forward thrust. Fig. 8 shows this construction, at present being tried in two kilns, one for calcining refractory clays and the other for hard-firing dolomite. Fig. 9 shows a design built with smaller shapes provided with tongues and grooves bonded together by overlapping joints. Heat-resisting tubes are used to provide reinforcement.

Some years ago a rotary dolomite calcining kiln was equipped with a quadrant construction as shown in Fig. 10. Rectangular tiles having double tongues and grooves were used. During the several years of service no repairs were necessary. Data on fuel consumption and the tonnage produced are not available.

Quadrant tile heat exchanger sections of limestone kilns generally are 20 to 30 ft long. Both longer and shorter sections have been tried, and this average range, at least tentatively regarded as optimum, is based on some appreciable experience. In some cases it has been considered best to install them at a distance of about 30 ft from the feed end, while in others they are used in the middle of the kiln, extending toward the feed end. Pending the availability of more definite information, generalization such as this cannot be avoided.

The accomplishments of the quadrant divider resulting in measurable economies may be briefly summarized as improved mixing of the charge, increased contact between the more turbulent gases and the charge, and greater internal refractory surface for the radiation of heat to the product.

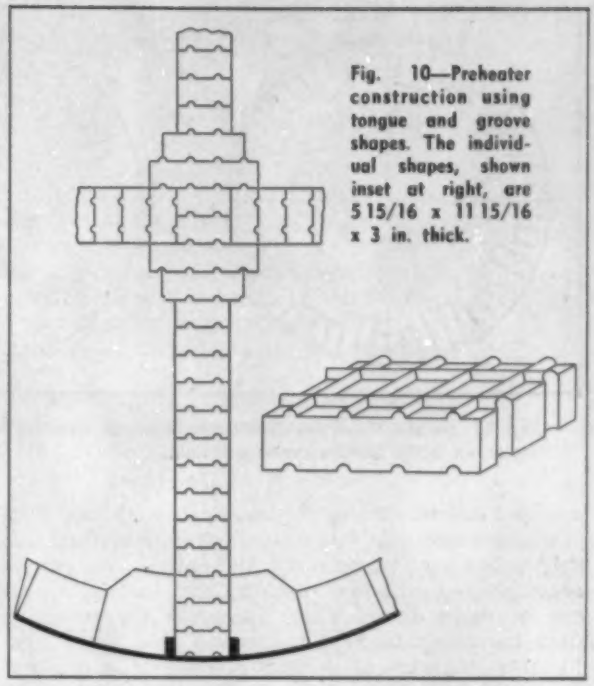
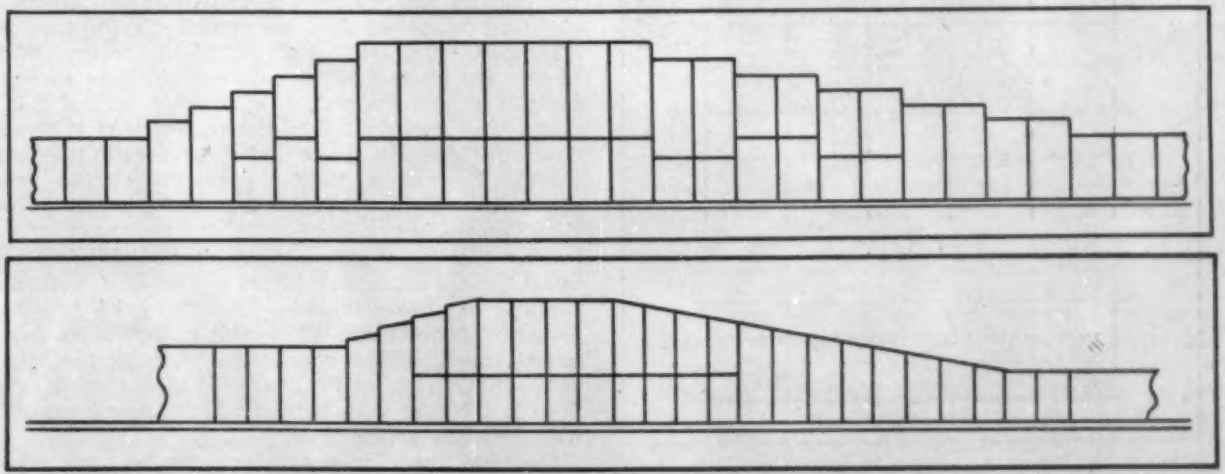


Fig. 10—Preheater construction using tongue and groove shapes. The individual shapes, shown inset at right, are 5 15/16 x 11 15/16 x 3 in. thick.

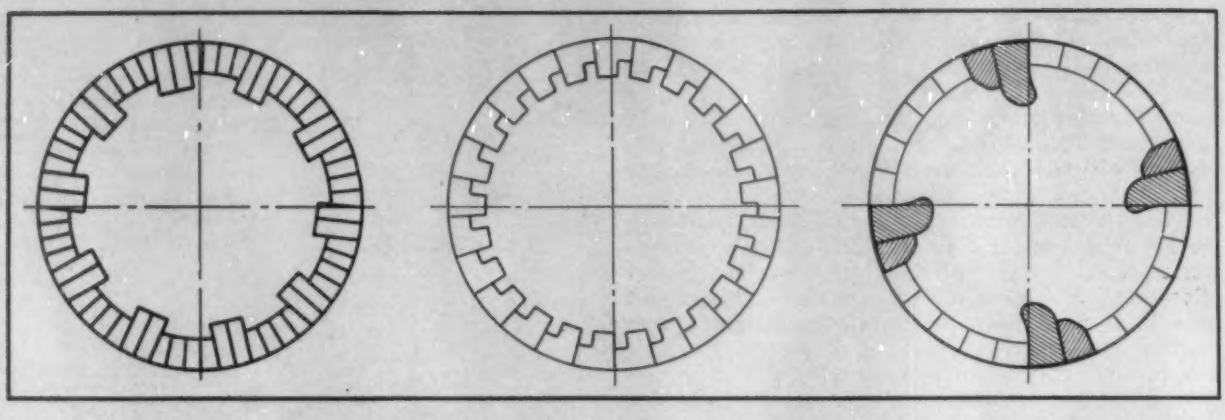
Available data on fuel savings and increased production resulting from the quadrant installations vary widely. Conservatively, typical figures may be regarded as 10 pct reduction in fuel consumption and 10 pct higher tonnage.

In appraising the value of this refractory accessory, it is necessary to take into consideration several factors, such as correct kiln loading, reduction of ring formation, and improvements in other operating variables, achieved with the use of quadrant dividers.

Dams: Among the refractory accessory constructions in any type of rotary kiln, probably the most widely used is the dam. For efficient operation, regardless of the product being processed, all the material must be subjected to the proper time temperature treatment. However, the rotary kiln is a material conveyor as well as a heat processing unit, and a large portion of the material, particularly the finest portion, comes to the top of the load only to



Figs. 11 and 12—Dams are usually built with standard rotary kiln blocks in a corbelled (upper view) or stepped arrangement (lower view) to a predetermined height. Some dams are built with special shapes, differing only in that the sides are chamfered to give a smooth contour to the dam so that flow of material will not be restricted.



Figs. 13, 14, and 15—A typical lifter arrangement consisting simply of longitudinal ribs is shown at left. More intricate patterns are shown in the sections center and right.

a slight extent during its travel through the kiln. It is important that the entire charge, including this submerged portion, be properly heated. This can be accomplished in some cases by the installation of one or more dams, which increases the retention time necessary to heat the entire load more uniformly. A series of dams will provide a uniform depth of load throughout the length of the kiln. Dams also help retard surging of materials which tend to flow nonuniformly throughout the length of the kiln. To control the velocity of gas and air they are frequently built at feed ends of the kilns, thus securing best combustion conditions and highest thermal efficiency. See Figs. 11 and 12.

Lifters: Highest thermal efficiency could be obtained only if each particle of the charge could be brought into direct contact with the hot gases. However, the charge always stays at the lowest part of the kiln and the hot gases pass over it. Moreover, the load or charge takes a set pattern in its journey through the kiln, the coarse particles revolving around the fines. Therefore, some method of mixing the charge with the hot gases and stirring it as it moves down the kiln would add greatly to the thermal efficiency. This has been done to a certain extent by the use of refractory lifters, which expose a portion of the load to a higher temperature by lifting it up and then cascading it down through the path of the hot gases. In addition, the refractory lifters break up the segregation of the particles and expose all portions of the load to the radiated and convected heat.

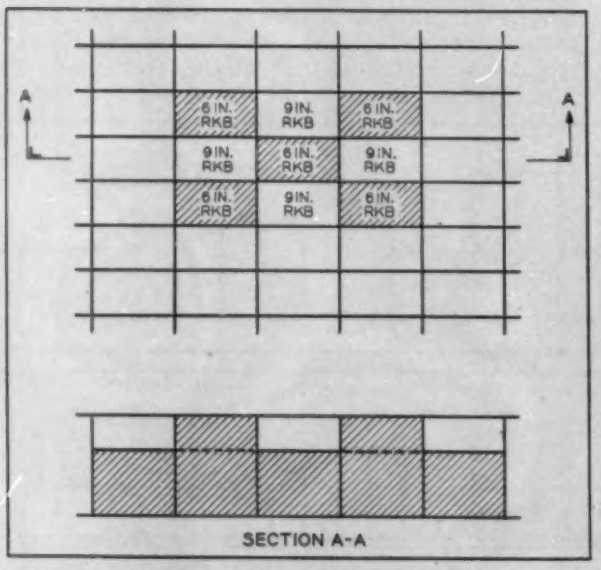


Fig. 16—The checkerboard or waffle-type lifter consists of a series of staggered pockets in the lining formed by alternate use of two brick shapes, one of which is considerably thicker than the other.

Several types of refractory lifter arrangements are in use in various rotary kiln operations. Most are simply longitudinal ribs, either straight or spiraled, Fig. 13. Some of the lifters constructed with special refractory shapes form intricate patterns in the lining. Figs. 14 and 15 illustrate two of these.

These lifter components are built of the class and type of refractory best suited for the particular zone of the kiln and the prevailing temperature conditions. However, the refractory lifter blocks are subjected to abnormally severe conditions because the portion of a block that protrudes above the lining proper is exposed on more than one surface. Consequently the lifters are subjected to more severe thermal spalling conditions and abrasive action than are the bricks in the lining proper. Because of this the maintenance costs in many cases outweigh the value of the fuel saving.

Checkerboard or Waffle-Type Lifter: Of the several types of lifter patterns that have been used, one has special merit. This is shown by Fig. 16. It consists simply of a series of staggered pockets in the lining formed by two brick shapes. The size of the pockets desired naturally determines whether standard or special sizes are needed. In the case of standards, 9x6x4-in. and 9x9x4-in. rotary kiln blocks are alternated in adjacent rings in such a manner as to form pockets up to 9x4 in. and 3 in. deep. The pockets retain the material as it flows down the kiln, lift it up, and then cascade it down through the path of the hot gases. This action improves the mixing of the charge and prevents particle segregation.

With this construction, many shortcomings of the usual type of refractory lifters are avoided, and the spalling conditions imposed upon the brick are reduced to a minimum. Since this pattern does permit straightline flow of material through the kiln, abrasion of brick by the charge is considerably less than is the case with lifters, which project inward from the face of the lining.

Greatest experience with this pocket type construction has been in the hottest zones of zinc recovery kilns in which the charge may become somewhat viscous, similar to putty.

Flotation of Quartz by Cationic Collectors

by P. L. de Bruyn

The adsorption density of dodecylammonium ions at the quartz-solution interface has been determined as a function of collector concentration and pH. A ten thousandfold range of amine salt concentration was covered at neutral pH. Experimental results show that over a thousandfold concentration range at neutral pH, the adsorption density (Γ) is proportional to the square root of collector concentration. Except at high concentrations, Γ increases with increasing pH, but in general this effect is surprisingly small.

A critical pH curve has been established for the flotation of quartz with dodecylammonium acetate. The conditions along the flotation curve are correlated with the adsorption measurements.

THE behavior of collectors at the mineral-solution interfaces is usually explained in terms of an ionic adsorption process. Through the distribution of collector ions between the solid surface and the co-existing solution phase the mineral is believed to acquire a water-repellent surface coating.

Quantitative adsorption studies have been made on simple flotation systems[1-4] only within the last few years. Such investigations were made possible by the adoption of the radiotracer method of analysis. As a consequence of these studies a new parameter has been added to aid the understanding of the flotation process.

The research investigation to be discussed in this paper was undertaken to obtain a better understanding of the behavior of a cationic-type collector. This objective was approached through the determination of the distribution of dodecylammonium acetate between the quartz-solution interface and the solution as a function of the collector salt concentration and pH. To bring this investigation to focus on the more practical aspect of flotation research, an attempt was also made to correlate the adsorption results with actual flotation tests.

Quartz: A −100 mesh ground crystalline quartz was infrasized; the products of the third and fourth cones were mixed together and reserved for experimental purposes. This stock material was cleaned by leaching in boiling concentrated HCl. After leaching the quartz was rinsed with distilled water until the filtrate showed no trace of chloride ion. It was then washed several times and dried. The quartz had a specific surface of 1400 cm^2 per g as determined by the krypton gas adsorption method.

Collector: The distribution of dodecylammonium acetate between the quartz surface and the solution phase was determined by the radiotracer method of analysis with carbon 14 as the tracer element. The radioactive amine salt with C^{14} synthesized into the hydrocarbon chain[5] was supplied by Armour and Co. The tracer element was located adjacent to the polar group. The radioactive salt as received had a specific activity of about 0.14 mc per g. When desired, dilution of this activity was effected by addition of non-radioactive dodecylammonium acetate also supplied by Armour and Co.

All other inorganic reagents used in this research were of reagent grade. Conductivity water was used for making up all solutions.

Adsorption Tests: Two different experimental methods were used. In the first, to be designated as the *agitation method*, a weighed amount of quartz and a measured volume of amine salt solution were agitated in a 100-ml or 50-ml glass-stoppered pyrex graduated cylinder. The cylinder was filled with solution up to the stopper, since erratic results were obtained when an air space was left over the suspension. Time of agitation varied from 1 to 2 hr. Preliminary tests at different agitation times showed that the amount adsorbed remained constant for all agitation times exceeding ½ hr.

After this conditioning period, the solids were separated from the solution by filtration through a Buechner fritted-disk funnel. The solution was recirculated 10 times or more to allow the fused silica disk to come to equilibrium with it. Determinations of the amount of amine adsorbed on the frit itself indicated that this amount was less than 10 pct by weight of the amine acetate abstracted by 10 g of quartz. The funnel with quartz covered by a thin layer of solution was then centrifuged for approximately 5 min, at which time the moisture content of the solids was reduced to about 5 pct by weight. The wet quartz was blown into a tared beaker, reweighed and allowed to dry at room temperature. A final weighing was then made to determine the moisture content.

The second experimental method, similar to the procedure adopted by Gaudin and Bloecher,[1] will be referred to as the *column method*. Two liters of solution were passed through a bed of quartz contained in a Buechner funnel attached to a pyrex separatory funnel by means of a ball and socket joint. Preliminary tests showed that increasing the volume of solution above 2 liters does not give a measurable increase in adsorption. From 4 to 4½ hr were required for 2 liters of solution to pass through the column. The moisture content of the quartz was again reduced to a minimum by centrifuging.

A slightly modified column apparatus was used for experimenting with alkaline amine solutions. The same basic unit was used, but the underflow from the Buechner funnel was again fed into a separatory

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funnel, which in turn was connected to a second quartz column. All contacts with the atmosphere were through ascarite-filled drying tubes. With this arrangement a precipitate of undissociated amine, when formed, would be collected in the first quartz-filled Buechner funnel. In these tests 4 liters of solution were passed through both quartz beds and the experiment required 8 to 10 hr for completion.

Carbonate-free sodium hydroxide solutions, for adjusting the pH in these tests and all other tests with alkaline solutions, were prepared by centrifuging a saturated aqueous solution of sodium hydroxide pellets. The clarified solution was stored in a plastic container, and from this stock solution dilute solutions were prepared at the time of experimentation. A model G Beckman pH meter was used for pH measurements. A special high-pH glass electrode was used to determine the pH at values greater than 9. To obtain reproducible readings in alkaline amine solutions the glass electrode was always rinsed and stored in a 1 *N* HCl solution.

Radioassay: The radioassay method consisted of the internal counting of radioactive carbon dioxide in a Geiger counter. Before radioassaying, the carbon content of the collector was converted to carbon dioxide by wet combustion. The combustion procedure and the counting technique have been described in detail in earlier publications.[6, 7]

Owing to the high resolving time (5.7×10^{-5} min) of these counters, the counting rate, whenever possible, was kept below 5000 cpm. Because the counting rate was kept below this maximum, the correction for resolving time to be applied to the observed count was less than 30 pct of the observed value. The active amine acetate as received could be used without dilution of its radioactive strength in tests where the solution concentration was 8.16×10^{-7} mol per liter (0.2 mg per l) or less.

To check the attainment of equilibrium and to obtain a material balance, it was important that both the solution and the quartz be analyzed, especially in the agitation tests. The quartz could be placed directly in the combustion flask of the wet combustion apparatus, but the amine in the liquid sample had to be concentrated prior to this combustion step. This was done by pipetting an aliquot sample of the solution to be assayed (5 to 20 cc) into a small pyrex cup. Seven to 8 mg of non-radioactive amine were then added to the sample to serve as a carrier and to yield the required pressure of CO_2 for filling the counter. This solution was made alkaline and allowed to evaporate to dryness at room temperature. The cup with its contents was then transferred to the combustion system for further analysis.

Vacuum Flotation Tests: The vacuum flotation technique used by Schuhmann and Prakash[8] in the study of the quartz-barium chloride-oleic acid system was adopted for the determination of the critical pH curves for quartz using different hydrocarbon chain-length amines. About 100 g of the same quartz used in the adsorption tests were stored under distilled water. The quartz was checked for grease and other organic contamination by determination as to whether it was floatable without the addition of collector. Usually the floatability of the quartz could be established simply by observation of the pneumo-flocculated condition of the pulp on repeated shaking of the cylinder. This condition was found to be due to the formation of small bubbles in the pulp which attached themselves to the quartz particles.

In most of the tests no additional frothing agent was added to the pulp, but comparative tests were run in which a few drops of a dilute solution of terpineol were added to the system. No difference in the flotation behavior could be observed among these tests and those with zero frother concentration.

Results

Solubility of Dodecylamine: When alkaline solutions are dealt with it is essential that the solubility of dodecylamine be known. Adsorption densities cannot be determined when dodecylamine is precipitating because in experimentation no distinction can be made between adsorbed amine and precipitated amine. Table I summarizes the experimental values for the solubility of dodecylamine as determined by three distinct experimental methods.

Table I. Solubility of Dodecylamine

Method	Solubility, Mols Per Liter	Temperature, °C
Light scattering	2.41×10^{-5} (average of five determinations)	20° to 25°
Adsorption measurements		
(a) Agitation test	1.98×10^{-5}	25°
(b) Column test	2.42×10^{-5}, 1.99×10^{-5}	28.5°
Potentiometric titration	2.02×10^{-5} (average of five determinations)	20° to 22.5°

The light scattering method involved the observation of Tyndall cone formation in aqueous solutions of known amine salt concentration and alkaline pH. In the adsorption measurements the clear equilibrium solution was radioanalyzed for amine content when a precipitate was oberved. In the agitation test, 67 ml of a solution which initially contained 1.95×10^{-4} mols per liter of radioactive dodecylammonium acetate were contacted with 8.55 g of quartz. The pH of the solution was 12.6. In the column tests the clear underflow solutions assayed 3.18×10^{-5} mols per liter and 2.53×10^{-5} mols per liter while the respective pH values were 11.1 and 11.2. The initial concentration of the salt was 4.08×10^{-3} mols per liter in both tests and definite precipitates were observed on the quartz beds. In calculation of undissociated amine concentration, a 4.3×10^{-4} value was used for the dissociation constant of the base.[9]

The values obtained by potentiometric titrations were determined by Brown.[10] This method consisted of a potentiometric titration of an aqueous dodecylammonium chloride solution with NaOH and with a

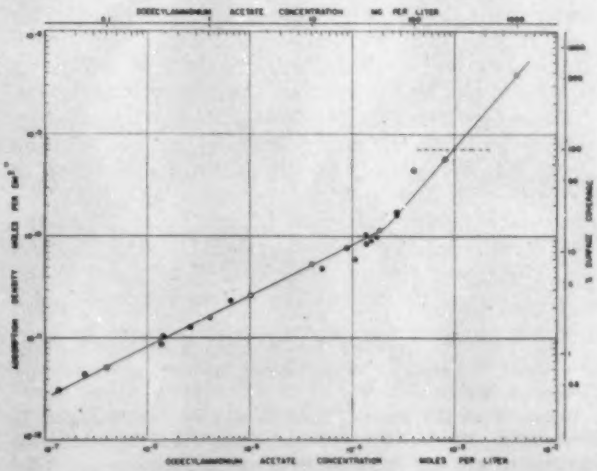

Fig. 1—Effect of dodecylammonium acetate concentration in solution on the adsorption density of the collector at neutral pH.

platinum black hydrogen electrode. Table I shows that the solubility values obtained by the various methods are in good agreement. A value of $2x10^{-4}$ mols per liter shall be assumed in this paper.

Adsorption Isotherm: Results of the investigation of the adsorption density of dodecylamine* on quartz for a ten thousandfold range of solution concentration and neutral pH are shown in Fig. 1. In this figure the solid circles represent the data determined by the agitation method and the open circles those obtained by the column method. The graph clearly illustrates that the relation between Γ (adsorption density) and c (equilibrium concentration of amine salt) is independent of the particular experimental procedure that was used. No attempt was made to control the temperature of the system, but the observed small variations in temperature (20° to 28°C) do not appear to have a systematic effect on the adsorption results. The pH of the solutions varied from 5.9 to 7.0; however, no consistent distribution of the experimental results with pH has been noted. Absolute pH measurements around neutrality are not possible in unbuffered solutions; only at high concentrations of the dodecylammonium acetate does the buffering action of acetate become important.

Fig. 1 illustrates a consistent variation of the adsorption density with collector concentration. In the concentration range, 10^{-7} mols per liter to $2x10^{-4}$ mols per liter, the experimental points group around a straight line with slope of one-half. Under these conditions of solution concentration, the experimental adsorption isotherm can be described by the empirical relation

$$\Gamma = 8.1x10^{-6}\sqrt{c}, \qquad [1]$$

where Γ and c have the dimensions of mols per cm^2 and mols per liter, respectively.

Beyond a concentration of $2x10^{-4}$ mols per liter, the surface concentration increases more rapidly with collector concentration. The following empirical equation describes this branch of the isotherm:

$$\Gamma = 2.2x10^{-6}\, c^{1.35}. \qquad [2]$$

The highest concentration of amine salt used in this investigation ($4.08x10^{-3}$ mols per liter) is still below the critical concentration of micelle formation ($1.3x10^{-2}$ mols per liter).

The percentage surface coverage may be obtained from the adsorption densities by assuming a value of 23.4 A^2 for the area per available surface site. This value was obtained by Gaudin and Rizo- Patron[11] from a sterical analysis of the arrangement of silicon and oxygen atoms at various crystal planes in quartz; it is also a good approximation of the cross-sectional area of the polar end of the amine molecule. Another important assumption was made in calculating the coverage, namely, that the amine molecule or ion is attached through its polar end perpendicularly to the quartz surface. According to these assumptions a monomolecular surface coverage will be obtained for an adsorption density of $7.1x10^{-10}$ mols per cm^2 or $4.3x10^{14}$ molecules per cm^2.

In the concentration range where Eq. 1 describes the adsorption isotherm the surface coverage varies from 0.14 pct to about 17 pct. Vacuum flotation tests showed that quartz will float readily at a pH between 6 and 7 from a solution of $2.04x10^{-4}$ mols per liter (5 mg per liter) of dodecylammonium acetate; a surface coverage of 5.3 pct is indicated under these conditions. Eq. 1 is applicable to the conditions at the solid-liquid interface in actual flotation operations where the collector concentration usually varies from 10^{-5} to 10^{-4} mols per liter. Above a concentration of $2x10^{-4}$ mols per liter where Eq. 2 is applicable, the surface coverage increases rapidly; a surface coating of 5.4 molecular layers deep is indicated at a solution concentration of $4.08x10^{-3}$ mols per liter

Gaudin and Bloecher[3] also investigated the quartz-dodecylammonium acetate system. Their isotherm has essentially the same shape as the adsorption curve in Fig. 1 and in the low concentration region these investigators also gave their isotherm a slope of one-half. However, the magnitude of the adsorption densities as determined by Gaudin and Bloecher is always approximately 40 pct lower** than the corresponding values obtained by this author.

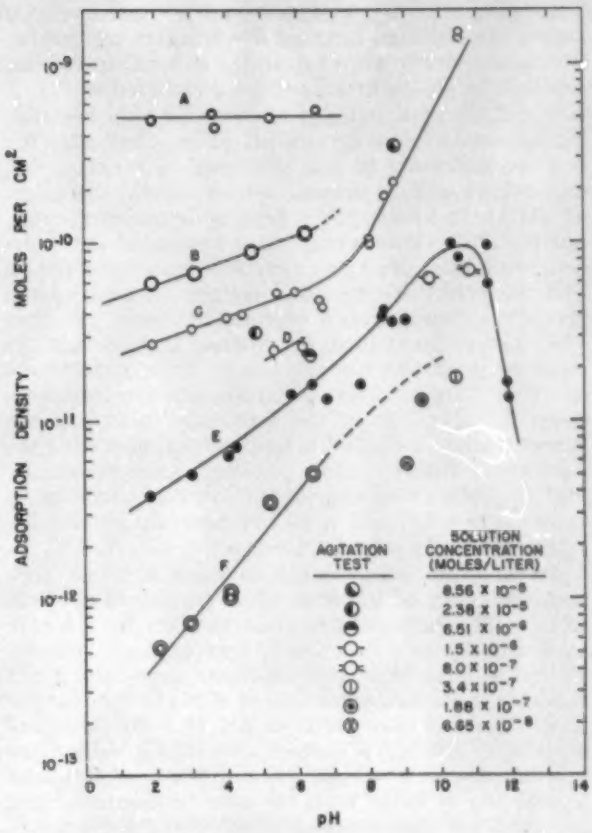

Fig. 2—Effect of pH on the adsorption density of the dodecylammonium ion at the quartz-solution interface.

Column Test	Solution Concentration, Mols Per Liter	Column Test	Solution Concentration, Mols Per Liter
A	8.16×10^{-4}	D	10^{-5}
B	1.85×10^{-4}	E	4.08×10^{-4}
C	4.08×10^{-6}	F	4.08×10^{-7}

Effect of pH on the Adsorption Density of the Collector: The variation of collector adsorption density with pH for five different solution concentrations ($8.16x10^{-4}$, $1.85x10^{-4}$, $4.08x10^{-5}$, $4.08x10^{-6}$, and $4.08x10^{-7}$ mols per liter) is represented graphically in Fig. 2. The effect of alkaline pH on the adsorption density has been investigated only at two collector salt concentrations, $4.08x10^{-5}$ and $4.08x10^{-6}$ mols per liter, since experimentation in the alkaline pH range

* By *adsorption density of dodecylamine* it is not to be understood that the author favors the undissociated amine as the adsorbing entity. This terminology is used for the sake of convenience. It should be obvious that no distinction can be made between the ion and the molecule in the experiment.

** The adsorption densities quoted by Gaudin and Bloecher should be multiplied by a factor 0.86 because these investigators used the less accurate value of 16.2 A^2 instead of the accepted value of 19 A^2 for the cross-sectional area of the Kr atom.

is complicated by precipitation of undissociated amine. In addition to these five solution concentration series which were run in the column apparatus, results of eight agitation tests are included in Fig. 2.

Fig. 2 shows a straight line relationship between log adsorption density and pH at constant collector salt concentration in acid solutions. For decreasing dodecylammonium acetate concentration, the effect of pH on the adsorption density becomes greater, but for all the concentrations investigated the magnitude of this effect is much less than anticipated. The slopes of the individual straight lines vary from zero at a concentration of 8.16×10^{-4} mols per liter (200 mg per liter) to approximately 0.24 at 4.08×10^{-7} mols per liter (0.1 mg per liter). At 8.16×10^{-4} mols per liter 73 pct of the quartz-solution interface is covered regardless of the particular pH. For the concentration, 1.85×10^{-4} mols per liter, and the concentration, 4.08×10^{-6} mols per liter, a ten thousandfold increase in the hydrogen ion concentration is accompanied by only a 50 pct decrease in the adsorption density of the collector.

An alkaline pH appears to have a more pronounced effect on the adsorption density of the collector. The amount adsorbed is seen to increase more rapidly as a function of hydroxyl ion concentration in basic than acid solutions, especially for a collector salt concentration of 4.08×10^{-5} mols per liter. The last two points at pH 10.5 for this concentration indicate a surface coverage greater than one monolayer; however, since on the assumption of a solubility of 2×10^{-5} mols per liter for the free base, precipitation should occur at pH 10.62, the experimental adsorption densities might actually include some precipitated dodecylamine. The spread in the points between pH 6 and pH 8 for both concentrations is largely due to the uncertainty in pH measurement.

The increased effect of alkaline pH on the adsorption density of the collector at a constant concentration of 4.08×10^{-6} mols per liter is less noticeable than at the higher concentration. Nevertheless, a greater increase in adsorption density per unit increase in OH^- concentration is indicated for the alkaline pH range up to a pH of about 10.5 than in the acid pH range. The distribution of points established by agitation tests helps in determining the location and shape of the adsorption curve. The sharp drop in adsorption density beyond pH 11 is of great interest.

Critical pH Curves: The experimental critical pH curves for the flotation of quartz with 8, 10, 12, 14, and 18 hydrocarbon-chain-length primary amine acetates are compared in Fig. 3. Flotation occurs under conditions above the curve for the specific collector, towards the left of the vertical line at pH 12.2 and towards the right of the dotted line at pH 1.4. Regardless of the specific collector and its concentration, it will be noted that the transition of quartz from a flotative to a nonflotative condition is obtained at substantially the same upper critical pH of 12.2. With decreasing pH of the pulp the lower critical pH is lowered with increasing collector concentration and is also dependent on the hydrocarbon chain-length of the collector. At high concentrations the lower critical pH approaches a value of 1.4 and is again substantially independent of the specific collector. The critical pH is not very well defined in the acid pH range and the transition from nonflotation to complete flotation extends at times over a whole pH unit, especially in the case of the octyl and decyl amines. It was noted sometimes on application of a vacuum to the cylinder immediately after agitation that the quartz does not float in acid solution, but after vigorous shaking by hand, the major portion of the quartz will float.

The similarity in shape of the critical pH curves is an indication that the same adsorption mechanism is involved in all instances. On account of the low solubility of the octadecylammonium acetate (approximately 3×10^{-4} mols per liter) the concentration range that could be investigated was limited.

The decrease in adsorption density of dodecyl amine above pH 10.5 at a constant collector salt concentration of 4.08×10^{-6} mols per liter, see Fig. 2, is in qualitative agreement with the observation of an upper critical pH.

Correlation of Adsorption Data with Flotation Conditions: Adsorption results may be used to supply quantitative information on the extent of the collector coating at the critical pH. In the past only the critical conditions within the solution phase which determine the floatability of the mineral could be determined. It should be realized, however, that the flotation system is characterized by a three-phase contact. The adsorption data obtained in this investigation refer only to the solid-liquid interface. Complete analysis of the flotation process will require, in addition to these data, a knowledge of conditions at the solid-gas interface.[13]

In Table II the observed surface coverage at the solid-liquid interface is given for different lower critical pH values from information contained in Figs. 2 and 3. In this analysis allowance is made for the accuracy with which the critical pH could be measured in the vacuum flotation tests. One value, pH 12.1, is included for the upper critical pH.

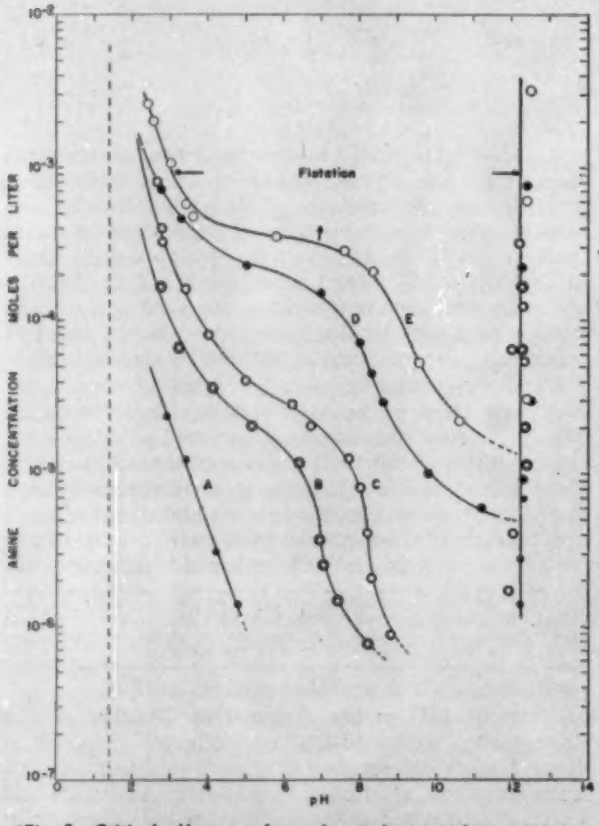

Fig. 3—Critical pH curves for various primary amine acetates.

Curve	Collector Salt
A	Octadecylammonium acetate
B	Tetradecylammonium acetate
C	Dodecylammonium acetate
D	Decylammonium acetate
E	Octylammonium acetate

The data of Table II are plotted in Fig. 4. In this figure the solid curve and the straight line trace the experimental critical pH curve for dodecylamine as collector. The small circles define the conditions in the solution phase for which surface coverages of the solid-liquid interface are available. The numerical value opposite each point identifies the percent surface coverage by the collector. Curve *ABC* is a curve of constant surface coverage of 5 pct; curve *GE* is the precipitation curve for dodecylamine based on a solubility of 2×10^{-5} mols per liter for this organic base. Towards the right of this curve and above the ordinate value of 2×10^{-5} the concentration of the undissociated amine remains constant. The continuous curve *FED* maps a constant dodecylammonium ion concentration of 5.4×10^{-7} mols per liter.

A study of Fig. 4 allows some interesting conclusions to be reached regarding the conditions which determine the transition between flotation and nonflotation of quartz at the solid-solution interface.

1—Below a concentration of approximately 10^{-4} mols per liter, the lower critical pH curve appears to be characterized by a critical surface coverage of 5 pct at the quartz-solution interface. Higher salt concentrations are needed at lower pH values to reach this critical coverage. The adsorbing entity appears to be the dodecylammonium ion.

2—Above a concentration of 2×10^{-5} mols per liter, the upper critical pH appears to be fixed by a critical dodecylammonium ion concentration of 5.4×10^{-7} mols per liter. Since flotation of quartz is still possible in zone *FEG*, a process involving molecular adsorption is not likely to explain the flotation behavior of quartz. In this concentration range of collector salt, the upper critical pH might be related to a critical 5 pct collector coverage of the quartz-solution interface. This statement, if true, assumes that pH is important here only in so far as it determines the concentration of the collector cation. However, no data are available to substantiate this statement nor could corroboration be obtained easily from conventional adsorption measurements.

3—Curve *ED*, which plots the proposed theoretical upper critical pH curve below the minimum collector concentration for precipitation of dodecylamine, is based on the attainment of a constant dodecylammonium ion concentration of 5.4×10^{-7} mols per liter and a constant 5 pct surface coverage. This

Table II. The Relation Between Critical pH and Surface Coverage at the Quartz-Solution Interface

Collector Concentration, Mols Per Liter	Critical pH	Adsorption Density, Mols per Cm^2	Surface Coverage, Pct
8.16×10^{-4}	2.4 ± 0.4	5.1×10^{-10}	72
1.85×10^{-4}	3.2 ± 0.4	7.0×10^{-11}	10
4.08×10^{-5}	5.0 ± 0.2	4.5×10^{-11}	6.4
2.04×10^{-5}	6.7 ± 0.2	3.7×10^{-11}	5.2
4.08×10^{-6}	8.2 ± 0.2	3.4×10^{-11}	5.0
	12.1 ± 0.2	1.0×10^{-11}	1.4

theoretical curve does not agree very well with the experimental curve; however, insufficient flotation tests have been made under conditions of low collector salt concentrations and high pH to establish accurately the trend of the experimental curve.

Too much significance should not be attached to the actual numerical values for collector concentration, adsorption density, or surface coverage and critical pH as quoted in this analysis. The order of magnitude of these values, however, should be noted. Gaudin and Chang[8] found that barium-activated quartz could be floated by sodium laurate at a

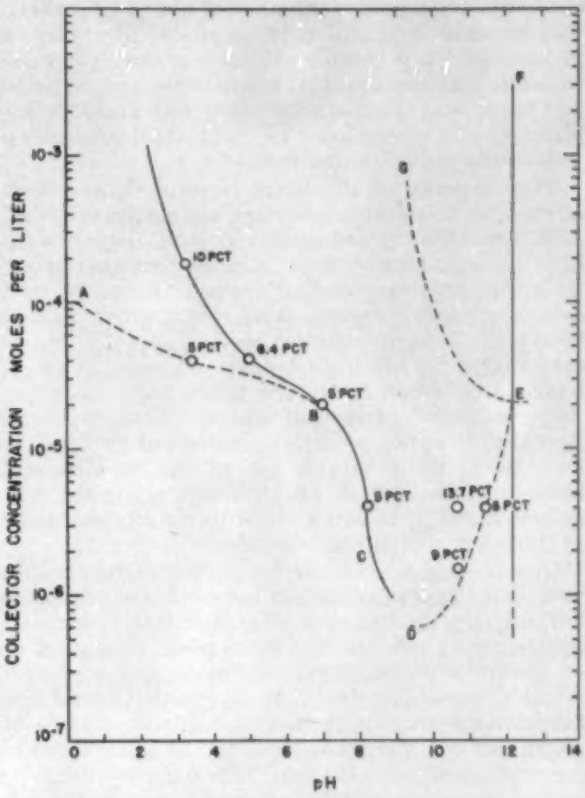

Fig. 4—Relation between surface coverage and the critical conditions in the solution phase at incipient flotation.

surface coverage of 4.5 pct as compared to the proposed 5 pct coverage of this mineral by dodecylammonium ions.

This experimental investigation also emphasizes an important difference between the action of an amine on quartz as compared to the behavior of xanthates on sulphide minerals. A monolayer of dodecylammonium ions at the quartz-solution interface is seen to develop at approximately 10^{-4} mols per liter and beyond this concentration a rapid build-up of multilayers is suggested. Contact angle measurements on various sulphides[13, 14] and adsorption density determinations on pyrite[15] again indicate that a monolayer of ethylxanthate at sulphide surfaces is never exceeded. Furthermore, monomolecular saturation of the surface is approached at a much lower concentration than is the case for the quartz-amine system.

From these contrasting observations it may be concluded that the xanthate ion or molecule has a stronger chemical affinity for a sulphide surface than the dodecylammonium ion for the quartz surface. Dodecylammonium acetate, like all colloidal electrolytes, forms micelles at high concentrations and, as suggested by Fuerstenau,[16] it is possible that the occurrence of multilayers at the quartz-solution interface could be explained by micelle formation close to the interface even though the critical concentration for micelle formation is not reached in the bulk solution phase.[17] The existence of ionic concentration gradients which extend from a charged interface into a co-existent electrolyte solution phase is well known and forms the basis for the treatment of the electrochemical double layer.

A Physical Model of the Quartz-Solution Interface: The above analysis of the experimental results has shown that it is possible to correlate adsorption

data with the flotation behavior of quartz. However, this correlation is still only empirical in nature; a causal relation is lacking. In view of the close relationship between colloidal phenomena and flotation processes, the application of the well-known electrical double layer model to this system might be a step in the desired direction.

The existence of an electrochemical double layer at the quartz-solution interface cannot be disputed. A silicon atom in the quartz crystal, owing to its high charge density, will tend to surround itself, whenever possible, by four oxygen atoms. When a quartz particle is fractured a large number of Si-O bonds are broken, thereby leaving some Si atoms surrounded by insufficient oxygen atoms. It seems logical that when fracturing takes place in water, water molecules will react with the exposed atoms. Actually, it is not water molecules but rather OH^- ions which move to one side of the fracture and unite with the surface silicon atoms, while the corresponding H^+ ions will unite with the oxygen atoms at the other side of the fracture.

Dissociation of H^+ ions from this *surface silicic acid* will be comparatively easy. Such a process will explain the negative charge of quartz in most aqueous solutions and the consequent formation of an electrical double layer. From careful measurements of streaming potential on quartz, Gaudin and Fuerstenau[18] concluded that the quartz surface is negatively charged above a pH of 3.72 and positively charged below this pH value. The positive charge at low pH values may be explained by a proton uptake of the surface OH-groups or surface oxygen atoms.[19] According to this model, as long as the system is far from saturation (complete surface dissociation) the pH will determine the surface potential or the double layer potential. In this respect the quartz should behave similarly to a glass electrode.

At present not enough information is available to extend the quantitative application of this model to the quartz-amine solution system. The important question to be answered is: To what extent does the magnitude and sign of the surface charge influence the action of the dodecylammonium ion at the quartz-liquid interface? Qualitatively, the increased adsorption density of the collector with increasing pH can be explained by the increasing negative potential across the double layer. Complete adsorption isotherms under acid and alkaline pH conditions are needed before the suggested potential-determining effect of pH can be fully evaluated.

Summary

Radioactive carbon-labelled dodecylammonium acetate was used in an equilibrium study of the adsorption onto ground quartz of the collector from solutions below the critical concentration of micelle formation.

The following information was gathered by the experimental studies:

1—The surface concentration of collector at a pH between 6 and 7 is proportional to the square root of the solution concentration over a thousandfold range of collector salt concentration. For concentrations greater than 2×10^{-4} mols per liter, the adsorption density increases more rapidly with change in solution concentration. A monolayer of adsorbed collector covers the surface at a solution concentration of 10^{-5} mols per liter compared to only an 11 pct complete monolayer at 10^{-4} mols per liter.

2—The change in adsorption density with varying pH in acid solutions at constant dodecylammonium acetate concentration depends on the particular concentration of the collector in solution: a—For concentrations above 2×10^{-4} mols per liter a hundred-thousand fold increase in hydrogen ion concentration has a negligible effect on the adsorption density of the collector. b—At concentrations of collector below this limiting value, decreasing the pH of the solution decreases the amount adsorbed. This effect is more pronounced the lower the concentration of the collector in solution.

3—In the alkaline pH range the surface concentration of collector increases with increasing alkalinity at constant total collector concentration. At a concentration of 4.08×10^{-6} mols per liter the surface concentration was observed to decrease rapidly above pH 11.

4—An upper critical pH which is independent of hydrocarbon chain-length and collector concentration was established for quartz. A lower critical pH which is a function of both collector concentration and hydrocarbon chain-length was also determined.

From an analysis of the experimental results, it may be concluded that the adsorption process appears to be controlled by the adsorption of the dodecylammonium ion and not the undissociated amine molecule.

A correlation of the experimental critical pH curve with adsorption data suggests that the lower critical pH, at collector salt concentrations below 10^{-4} mols per liter, is reached when a critical surface coverage of 5 pct is approached at the solid-liquid interface. Above 2×10^{-5} mols per liter of total collector concentration the upper critical pH is reached when a critical dodecylammonium ion concentration is approached. The same critical ionic concentration is postulated to determine the position of the upper critical pH in solutions where the solubility of the undissociated collector molecule is not exceeded. In addition, there are indications that a critical 5 pct surface coverage also determines the position of the critical pH.

Acknowledgments

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Abstract

Exhaust Dust Control in Dry Percussion Drilling

I. Formation of Cuttings

by Howard L. Hartman and Eugene P. Pfleider

Basic relations of drilling energy to speed and particle size and number of cuttings afford a means of predicting percussion drill performance and minimizing the attendant problems of cuttings removal and dust control in dry drilling.

II. Ejection of Cuttings

by Howard L. Hartman

Air is established as an ejection fluid superior to water, and many factors are evaluated that influence the liberation of cuttings and hence dust control and drilling speed.

III. Capture of Cuttings

by Howard L. Hartman

Attention to the design of a drill exhaust hood results in minimum air requirements and power consumption, with the attainment of dust control and penetration rates unsurpassed in wet drilling.

IV. Pneumatic Transport of Cuttings

by Howard L. Hartman

Empirical equations are obtained for calculating transport velocities and pressure drops in pneumatic conveying, and a dust control system is designed for use with any percussion air drill.

H. L. Hartman is Assistant Profesor of Mining Engineering, Colorado School of Mines, Golden, Colo., and E. P. Pfleider is Head, Department of Mineral Engineering, University of Minnesota, Minneapolis.

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Chemistry of the Ammonia Pressure Process for Leaching Ni, Cu, And Co from Sherritt Gordon Sulphide Concentrates

by F. A. Forward and V. N. Mackiw

ABSTRACT

The paper relates to the laboratory and pilot plant studies that have been carried out by Sherritt Gordon Mines Ltd., Metallurgical Research Div., in developing the ammonia pressure leach process for extracting Cu, Ni, Co, and S from high grade Ni concentrate produced from Lynn Lake ores and describes in some detail the chemistry of the process.

In the leaching stage air, ammonia, and sulphide minerals react in a sequence of inter-related steps to produce soluble amines of Ni, Cu, and Co in a solution containing sulphate, thiosulphate, polythionate, and sulphamate ions and a controlled amount of free ammonia, the iron and other components of the concentrate remaining as an insoluble residue which is separated from the leach solution by filtration. The pregnant solution produced in leaching is further treated by boiling to precipitate and remove Cu as cuprous sulphide, leaving a copper-free solution with a composition suitable for subsequent precipitation of Ni and Cu by H_2.

The progress of individual reactions in leaching and copper removal is discussed. The effect of variables such as temperature, pressure, ammonia concentration, particle size, and agitation is outlined and the technique of thionate control in leach solutions is described. Data is given for the physical and chemical reactions involved in precipitating copper from leach solutions as Cu sulphide by boiling.

The article from which the above abstract is taken appears in AIME *Trans.* v. 203, p. 457; JOURNAL OF METALS, March 1955.

Replacement and Rock Alteration In the Soudan Iron Ore Deposit, Minnesota

by George M. Schwartz and Ian L. Reid

THE Soudan mine in the Vermilion district of northeastern Minnesota is the oldest iron mine in the state. It has shipped ore every year since 1884 and still contributes a yearly quota of high grade lump ore.

No comprehensive report on the Vermilion iron-bearing district has appeared since Clements' monograph,[1] but Gruner[2] discussed the possible origin of the ores in 1926, 1930, and 1932, and recently Reid and Hustad have added data on mining and geology.[3, 4] For many years geologists of the Oliver Iron Mining Div., U. S. Steel Corp., have kept up to date a series of plans and vertical sections of the Soudan mine. In connection with mine operation considerable diamond drilling has been done, and this, together with the mine openings, has permitted a reasonably accurate picture of the structure of the orebodies and wall rocks.

It has long been evident to geologists familiar with the mine that the ores were not a result of weathering, a point emphasized by Gruner in 1926 and 1930. As the deeper orebodies were developed it also became clear that replacement had played an important part in their development. In recent years it has been recognized that other iron ores were formed by replacement, as Roberts and Bartly[5] have argued strongly for the deposits at Steep Rock Lake. On the basis of these facts G. M. Schwartz suggested to members of the Oliver staff that it would be desirable to study the evidence of replacement, particularly the possible alteration of the wall rock which would be expected if the replacement was a result of hypogene solutions.

Rock Formations: The formations directly involved in the iron orebodies of the Soudan mine are few though far from simple. The country rock is largely the Ely greenstone of Keewatin age consisting of a mass of metamorphosed lava flows, tuffs, and intrusives which have been more or less altered by hydrothermal solutions. The predominant rock is chlorite schist.

Interbedded with the original flows and tuffs are a series of beds and lenses of jasper to which the name *Soudan formation* has been applied. In the Vermilion district the term *jaspilite* has been used for interbanded jasper and hematite. According to modern usage these jasper or jaspilite beds do not comprise a formation separate from the Ely greenstone, inasmuch as the beds of jasper are interbedded with the flows and tuffs of the upper part of the greenstone. It would more nearly accord with modern usage to consider the Soudan beds a member of the upper part of the Ely formation.

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Because of incomplete rock exposure and exploration the number of interbedded jaspilite beds is unknown. In the mine, however, as many as nine major beds of jasper are known on a cross-section of one limb of the syncline, with an equal number on the other limb. In addition diamond drill cores show beds of greenstone down to half an inch in thickness. The thin beds are probably always tuffs.

Structure: Rock structure in the Soudan area is complex, and because there are no recognizable horizons within the greenstone it is extremely difficult to work out the details. Generally speaking, the major regional structure is an anticlinorium, the axis trending east-west, with a westerly pitch. The Soudan mine is related to a synclinal structure on the north limb of the anticline about a mile from the west nose of the folded iron formation.

The general structure at the mine is that of a closely folded minor syncline on the major regional anticline. A cross fault has dropped the east side so that the bottom of the syncline has not been reached, whereas to the west it is well shown by the mine openings and diamond drill exploration. Throughout the mine the beds of jasper, and orebodies that have replaced the jasper, normally dip northward at angles of 80° or steeper. In detail the jasper beds are extremely folded, probably as a result of deformation while they were still relatively unconsolidated.

Orebodies: Ore in the Soudan mine is mainly a hard, dense, bluish hematite. Locally ore has been brecciated and cemented by quartz. The vugs commonly occurring near the borders of orebodies are lined with quartz crystals. They seem to have formed as part of the ore-forming process and are evidence that no folding or compression of the ore has taken place.

The orebodies are numerous, varying greatly in size. Many lenses of high grade hematite are too small to be mined. Some of the larger orebodies have been followed vertically for as much as 2500 ft and horizontally up to 1500 ft. The large orebodies are extremely irregular in outline in the plane of the beds of jaspilite. In width they are more regular, as they are strictly governed by the width of the jaspilite beds and the greenstone wall rock, which seems to have resisted replacement by hematite. At many places the orebodies replace the jaspilite completely and have a footwall and hanging wall of greenstone. At other places either one or both walls may be jaspilite.

Geologists who have studied the orebodies in recent years agree that evidence for the replacement origin of the hematite bodies seems conclusive. As noted above, many of the orebodies replace jaspilite beds from wall to wall with no evidence whatever of compaction.

The replacement origin is also supported by details of the banding which is characteristic of the

jaspilite beds. Particularly at the ends of the orebodies bands of jasper may be seen to fade into solid hematite. In the gradational zone remnants of jasper of every conceivable size and shape remain in the hematite, but in general the gradation is surprisingly abrupt. Solid hematite often faintly preserves the banding of the original jaspilite, although in the bulk of the ore the banding has been largely destroyed. It may be roughly estimated that a cubic foot of jaspilite weighs somewhat less than 200 lb, whereas a cubic foot of high grade ore of the same volume weighs about 360 lb. Therefore the mass of iron added to form the orebodies was great indeed.

In lean rock adjacent to the orebodies there are abundant veinlets of hematite which cut the jaspilite bands and appear to be replacements rather than filling of open fractures.

Erratic deposits of chalcopyrite, native copper, and pyrite, as well as vein quartz and specular hematite, indicate that hydrothermal solutions have been at work in the ore.

Wall Rock Alteration: If the replacement origin of the massive hematite bodies is accepted a problem arises regarding the nature of the ore-bearing solutions and accompanying effects on the wall rock. This difficulty was encountered at once when work was started on the surface geology of the Soudan area in 1951. Before exploration was continued the problem of the alteration and its relation to the orebodies was presented to the Oliver Iron Mining Div. and permission was received to examine the underground openings and drill core.

One of the striking features of the geology of the mine is the abundance of a light yellow sericite schist closely associated with the ore. Two possible origins present themselves: 1) The rock may be metamorphosed rhyolite flows or rhyolite porphyry intrusions. 2) It may represent alteration and replacement of the more basic greenstone.

Although the true origin of this rock is still a matter of debate, its character has been studied in thin section, and a chemical analysis of a typical drill core sample has been made.

A comparison of the sericite schist with typical greenstone shows that the silica and potash are much higher in the sericite rock and that ferrous iron, magnesia, lime, and soda are lower. Carbon dioxide is abundant in the complete analysis, but two other determinations on different samples indicate that this is not necessarily typical.

The close association of the sericite schist with the ore at the Soudan mine suggests a genetic relation, particularly because the sericite rock is rare elsewhere in the area. The chemical and mineralogical nature, on the contrary, indicates an original rhyolitic rock. It is hoped that detailed mapping based on underground work and re-examination of drill cores will permit a solution of the problem of origin of the sericite schist.

Table I. Chemical Data on Sericite Schist

Item	Sericite Schist			
	Hole 708 at 175 to 210 Ft, 12th Level	200 N-160 W, 12th Level	Hole 630 at 89 Ft, 20th Level	Hole 818 at 20 Ft, 17th Level
SiO_2	59.71			
Al_2O_3	16.05	18.26	11.25	14.44
Fe_2O_3	0.73		Fe 0.45	Fe 2.34
FeO	1.81			
MgO	2.78			
CaO	4.55		trace	trace
Na_2O	0.51			
K_2O	4.18			
H_2O+	2.07			
H_2O-	0.29			
TiO_2	0.28			
P_2O_5	0.16	0.38	0.16	0.44
CO_2	6.40		0.03	0.24
MnO	0.15			
Total	99.67			

Greenstone Wall Rock: In connection with the study of the sericite wall rock an analysis of a typical greenstone near an orebody was desirable. Accordingly a section of diamond drill core was selected from a hole on the 19th level at a point 100 ft from an orebody. In this analysis the greenstone was 23.28 pct ferrous iron, two to three times higher than that of any previously analyzed greenstone from the Ely formation; the silica content of 31.85 pct is correspondingly low. Examination of a thin section from the analyzed core showed that the rock consists largely of chlorite, and in view of the low magnesia content (1.33 pct) the chlorite is necessarily a high iron chlorite, a fact verified by an X-ray determination. Calculations using the chemical analysis indicate about 58 pct chlorite, of which 54 pct is the iron chlorite molecule. In addition to chlorite the thin section contains sericite, kaolinite, hematite, leucoxene, and rutile. Veinlets of sericite are bordered by chlorite. Some have kaolinite and probably other clay minerals in the center. The amount of potash, 4.18 pct, indicates about 25 pct of sericite in the rock.

These results suggest a large degree of replacement of the wall rock during formation of the hem-

Table II. Chemical Data on Greenstone

Item	From Drillhole on 19th Level	From Drillhole on 22nd Level, North Wall of Montana Orebody	From Drillhole on 20th Level	From Surface Drillhole	From Drillhole on 19th Level	Sample from 19th Level	From Drillhole on 15th Level	M4011, Greenstone from Outcrop, Sec. 9, T. 61 N, R. 14 W	Average of All Known Analyses of Normal Ely Greenstone
SiO_2	31.85							49.72	
Al_2O_3	27.93							16.76	
Fe_2O_3	2.15	5.6	12.5	2.7	1.0	2.5	5.82	1.92	2.07
FeO	23.38	26.3	24.7	20.3	12.6	12.1	14.46	7.33	7.66
MgO	1.33							7.62	
CaO	0.04							9.35	
Na_2O	0.43							3.14	
K_2O	3.26							0.71	
H_2O+	8.12							1.57	
H_2O-	0.48							0.06	
TiO_2	0.84							0.89	
CO_2	0.04							0.10	
P_2O_5	0.08							0.09	
MnO	0.08							0.16	
Total	99.98					BaO		0.06	
						S		0.04	
								Total 99.51	

atite ore. Further data was necessary before any firm conclusion could be drawn and several greenstone drill cores from wall rock near ore were analyzed for FeO, Fe_2O_3, and total iron, as shown in Table II.

Six samples, ranging from 12.1 to 26.3 pct, averaged 19.12 pct ferrous iron. An additional sample collected from a single flow many miles from known ore showed only 7.3 pct ferrous iron. As an average of the ferrous iron in five previously analyzed greenstones was 7.22 pct, for practical purposes 7.5 pct ferrous iron may be considered normal. There is little doubt, therefore, that the greenstone wall rock of the orebodies has been altered by a large addition of ferrous iron, combined water, and possibly some addition of alumina, assuming that the greenstone of the wall rock was originally a normal type. Although this cannot be proved it is believed to be a reasonable supposition.

Paint Rock: At many places in the Soudan mine another type of wall rock alteration occurs, a soft red rock referred to as *paint rock* in the mine. Discovery of the high ferrous iron content in the greenstone rock has clarified the origin of the paint rock, which appears to be an oxidation product of greenstone. A sample of paint rock, one of many from the drill core, was selected only a foot away from the greenstone. Analysis showed the conspicuous difference to be a conversion of ferrous iron to ferric iron. The silica is lower, see Table III, and the combined water much lower, as would be necessary if ferrous iron of chlorite were converted largely to hematite as it apparently has been here.

Table III. Analysis of Greenstone and Paint Rock Samples

Item	No. 3521 Greenstone from Drillhole on 19th Level	Paint Rock from Same Drillhole
SiO_2	31.85	25.29
Al_2O_3	27.93	19.61
Fe_2O_3	2.15	38.16
FeO	23.38	6.44
MgO	1.33	0.40
CaO	0.04	0.29
Na_2O	0.43	0.42
K_2O	3.26	3.74
H_2O+	8.12	3.80
H_2O-	0.48	0.70
CO_2	0.04	0.08
TiO_2	0.81	0.68
P_2O_5	0.08	0.19
MnO	0.08	0.02
Total	99.98	99.82

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Structure and Mineralization at Silver Bell, Ariz.

by Kenyon E. Richard and James H. Courtright

DISCUSSION

Thomas W. Mitcham *(Strategic Minerals, Inc., Grand Junction, Colo.)*—The authors have presented a significant contribution to the field of mining geology. The article is graphic, remarkably concise, and crisply original. The presentation is made on only three pages with two maps, but their Silver Bell story is entirely adequate in background, development, and conclusion. Most of their colleagues would agree that this paper reflects the high quality of the work which these unusually capable men have done in the Silver Bell area over the past few years.

The Silver Bell area is one of complex tectonic structure, and time and spatial relationships are by no means apparent. Actually, most of the observations and interpretations in this paper are new to published geologic literature on the Silver Bell area. I am in agreement with these interpretations with two possible exceptions, which are discussed below.

One might well define the three roughly parallel west-northwest faults, shown on the insert of Fig. 2, as the major structural elements of the area. North to south, I propose that these be named the Ragged Mountain fault, the Silver Bell fault zone, and the Waterman thrust, after the mountain ranges which are the results of these major structures. While I would agree with the authors that the northern two of these major structures are high-angle faults of the Laramide revolution, my impression is that the southern structure is a low-angle thrust of approximately Miocene age. In support of this opinion, I submit the following observations: 1) irregularity of the fault in strike; 2) scarcity of Laramide intrusives and alteration of sediments along the fault; 3) present high relief of the Waterman Range which indicates youth or certainly rejuvenation; and 4) existence of a series of parallel structures farther to the south which results in an outcrop pattern suggesting imbricate thrusting.

The authors have stated that Laramide igneous activity began with the intrusion of alaskite. Some dacite flows appear to be conformable with Cretaceous beds, and thus my impression was that alaskite followed the intrusion and extrusion of dacite. I would be interested to learn of evidence in support of the reverse relationship suggested by the authors.

Kenyon Richard and J. H. Courtright *(authors' reply)*—The authors appreciate Mr. Mitcham's attention to this paper. The names he proposed for the major faults seem appropriate. His suggestion that the Waterman fault is a thrust may be correct because he did more work in that particular area than the authors. However, it is believed that no direct evidence of a low-angle thrust relationship has been recognized, and the authors consider that indirect evidence favors a high-angle fault interpretation.

The pre-dacite flow age of the alaskite is definitely established, the authors believe, by the fact that the flows rest on an erosion surface which was carved in the dacite porphyry, an intrusive clearly younger than the alaskite, as evidenced by inclusions of alaskite occurring in dacite porphyry. No direct evidence of Cretaceous sediment-flow rock relationships was found at Silver Bell, but in the nearby Tucson mountains dacite agglomerates, megascopically similar to those at Silver Bell, overlie a basal conglomerate which in turn rests on the truncated edges of steep-dipping Cretaceous arkosic beds.

aime news

Frank Marr Heads Committee For Pacific Northwest Regional Conference At Spokane, April 28 to 30

Plans for the Pacific Northwest Regional Conference to be held in Spokane on April 28, 29, and 30 are progressing nicely according to A. Y. Bethune, Sullivan Mining Co., Kellogg, Idaho, General Chairman.

Frank N. Marr, president, Spokane-Idaho Mining Co., has accepted chairmanship of the Committee on General Arrangements in

A. Y. BETHUNE
General Chairman

Spokane, handling all facilities at the Davenport Hotel, headquarters for the conference, as well as other matters such as registration, finance and publicity. Working with him will be Karl Jasper, president, Grandview Mines, and Hamilton Owen of the Spokane Chamber of Commerce.

W. M. Armstrong, dept. of mining and metallurgy, University of British Columbia, Vancouver, has been appointed as Chairman of the Div. of Physical Metallurgy and Lee W. Heinzinger, metallurgical supervisor, Bethlehem Pacific Coast Steel Co., Seattle, Wash., has been appointed Chairman of the Div. of Iron and Steel for the conference sessions.

F. R. Morrall reports that one of the features of the conference will be a symposium on X-ray fluorescent analysis. This program is planned to be of interest to most members of the AIME such as geologists, mining engineers, chemists, extractive and physical metallurgists, and anyone interested in industrial minerals and minerals beneficiation.

A technical session Saturday morning will be followed in the afternoon by a demonstration session on X-ray fluorescent analysis. In the morning technical session there will be a brief description of the principles of the method. This will be followed by a discussion of analytical precision and statistical aspects of metallurgical plant control. The speakers will present actual data on the application of X-ray fluorescent technique to mineral and metallurgical products, and its application to industrial hygiene and toxicology. X-ray fluorescent analysis results will be given on soil, ores, concentrates, tailings, slags, and alloys. The speakers at the technical session will be F. A. Hames, head of the dept. of metallurgy at the Montana School of Mines, Butte, Mont., D. M. Mortimore, head of the physics laboratory, U. S. Bureau of Mines, Albany, Ore., and P. A. Romans, also of the USBM, Albany.

Among the specific topics to be discussed will be tungsten ores, concentrates and tailings, hafnium in zirconium ores, and production plant products, columbium, tantalum, uranium, thorium, and various rare earth elements in the complex ores. Materials related to more common metals will also be presented.

In the afternoon apparatus will be on display to demonstrate X-ray fluorescent analysis techniques and to run samples for interested parties.

Send Coupon For New AIME Directory

During the month of June, a new all-Institute Directory will be issued. This publication will contain an alphabetical and geographical listing of all members on the Institute records, Feb. 1, 1955. In addition, the Directory Supplement listing all officers, Branches, Divisions, Local Sections, Student Chapters, and committee personnel will be included with this volume.

However, increased costs for producing this type of material have made it necessary to alter the procedure of past years. The Directory will be mailed only to those members in good standing who request it by filling out and mailing the coupon below. This is important, as requests by letter will not be acknowledged. Each request for the Directory must be made with the coupon. Subsequent announcements will be made concerning the Directory, but the coupon appearing in this issue of the magazine will be the only valid requisition for the book. Fill in the coupon and mail to AIME, 29 West 39th St., New York 18, N. Y.

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Report on Local Section Finances

A special task committee on Local Section Finances (T. B. Counselman, Chairman, with A. B. Kinzel, Gail F. Moulton, M. B. Penn, H. DeWitt Smith, and Clark Wilson) reported at the December 15 meeting of the AIME Executive and Finance Committees. The Committee recommended that the Council of Section Delegates be reduced in number to between 20 and 30, inasmuch as the larger Council was unwieldy and it had been a considerable drain on the Institute treasury to pay the expenses of delegates from 60-odd Local Sections to the Annual Meeting. Instead, it was proposed to allow two delegates from each of the ten AIME Directoral districts, with additional delegates from the seven outlying Local Sections not embraced in any of the Directoral districts. A rotational plan would be devised for selecting the delegates from the various Local Sections in the respective districts. The Committee recommended further that in 1956 the rebate to the Local Sections be increased from 50¢ to $1 provided the budget could be balanced if such a rebate were paid. A bottom limit of $100 per Section would, however, be established. (In 1955, travel expenses of delegates from each Local Section have been authorized, so the rebate would not be increased until 1956). The Committee felt that the rebate to Local Sections of half the initiation fees paid by new members in their respective territories should be continued, and should be expanded to include half the initiation fees paid by Junior Members who advance to a higher grade. If an employer were willing to pay a delegate's expenses, the Committee felt that he should not accept expenses from the Institute.

The Committee's recommendations have been referred to the Council of Section Delegates for consideration.

Local Sections Approved by AIME

Three new sections, consisting essentially of Petroleum Branch membership, were given final approval by the Institute's Executive Committee recently.

The Illinois Basin Petroleum Section supercedes the Illinois Basin Chapter of the Petroleum Branch and includes all Petroleum Branch members in the St. Louis section area. The Venezuela Section is the second of those gaining approval. The Section embraces the entire republic. A local section was organized in that country in 1947 but was forced to disband because of a law which forbid local chapters of foreign societies.

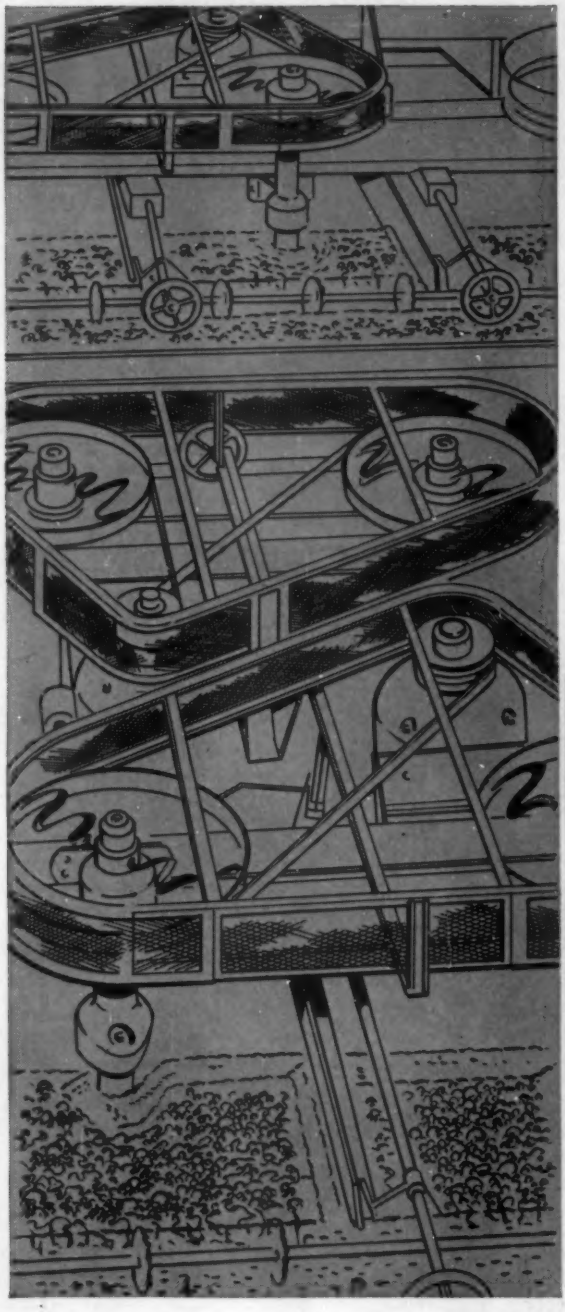
Third group to gain recognition is the New York Petroleum Section. Petroleum Branch members of the New York Section were released to form the Petroleum Section. Its membership is drawn from the same geographic area as the mining and metallurgy membership of the original New York Section.

The following sections have also been established by action of the AIME Board.

Panhandle, consisting largely of Petroleum Branch members in the Panhandle area of Texas. Counties embraced in the new Section's area were listed on page 49 of the JOURNAL OF PETROLEUM TECHNOLOGY for July 1954.

Hugoton, consisting of an area in Texas, Oklahoma, Colorado, and Kansas as specified in the July issue of JPT. The new Section was formerly organized as the Tri-State Gas and Oil Assn.

Niagara Frontier, a Section in an area not previously included in the territory of any Local Section—western New York State. The following counties are included; Cayuga, Tompkins, Chemung, Seneca, Wayne, Monroe, Ontario, Yates, Schuyler, Steuben, Livingston, Allegheny, Wyoming, Cattaraugus, Chatauqua, Genessee, Orleans, Niagara, and Erie. Headquarters will be in Buffalo or Niagara Falls. The organizing committee consisted of D. Swan, Chairman; Walter Crafts, D. C. Hilty, I. S. Servi, and H. R. Spedden.



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Around the Sections

• The newly formed **Niagara Frontier Section** held its first regular meeting at the Red Coach Inn, Niagara Falls, N. Y., with 55 members and guests present. Leo F. Reinartz, now Past President of the AIME, and E. H. Robie, AIME Secretary Emeritus, were the speakers. David Swan is Section Chairman.

• James R. Wilson has been elected chairman of the **Reno Subsection.** Other officers elected were R. L. Reeves, Vice Chairman, and A. L. Engel, Secretary. Judge Clark J. Guild spoke on the history of the Nevada State Museum at Carson City. Twenty-eight members of the subsection attended the meeting.

• At the February meeting of the **New York Section,** Sherman White, mine superintendent at Nicaro, discussed the operation, metallurgical problems, and the leaching system at the National Lead Co. operation in Cuba. He also went into Nicaro expansion plans. The meeting was held at the Mining Club.

• *Movement is Life* **is the new 20 min 16-mm motion picture sponsored by the Conveyor Equipment Mfg. Assn., Washington 5, D. C. The scope and variety of conveyors throughout the nation's industry are depicted in scenes of actual installations. Black and white prints may be borrowed from Modern Talking Picture Service, 45 Rockefeller Plaza, New York, N. Y.**

• **Bucyrus-Erie Co. has a sound 16 mm color movie called** *That Extra Margin.* **It covers the story of advanced engineering in Bucyrus-Erie quarry and mine excavators, showing the machines actually at work. Still art animation is also used to get the company's message across. This is the first industrial film to use the new Eastman negative color process. Write Bucyrus-Erie Co., Publicity Dept. South Milwaukee, Wis.**

• *Mining on the Move,* **a 14-min sound and color movie picturing modern haulage and materials handling methods used in a wide variety of mining operations has been produced by LeTourneau-Westinghouse Co., Peoria, Ill. The film shows Tournapull scrapers working diamond mines and iron mines; rear dumps in bauxite, iron, gypsum, and copper mine applications; and rubber-tired dozers at titanium, magnetite, and gypsum mines. The film also shows equipment in clean-up operations at the dump and around shovels, and other typical mining applications. Inquiries should be directed to the nearest LeTourneau-Westinghouse distributor, or the advertising dept., LeTourneau-Westinghouse Co., Peoria, Ill.**

PERSONALS

W. Church Holmes has left his position as metallurgist and mining engineer with Sunshine Mining Co., Spokane, to become general manager of the Mohawk mine and mill, a Bru-Hi Enterprise operation in Esmeralda County, Nev.

Ray C. Hansen has returned as division manager, M & M Wood Working Co.'s National Tank & Pipe Div., Portland. Mr. Hansen, who was an executive and division manager of this company from 1919 to 1952, will initiate and operate a new plastic pipe plant.

Frederick F. Franklin, formerly assistant district manager, Cleveland office, Vanadium Corp. of America, is now district manager.

George B. McMeans, vice president in charge of Kaiser Steel Corp.'s steel making and raw materials operations, has transferred his office from Kaiser's Fontana, Calif., plant to the executive offices in Oakland, Calif.

L. C. Campbell, president of Eastern Gas & Fuel Co., Pittsburgh, was re-elected president of the National Coal Assn.

Floyd B. Bowen, manager of the Florida dept., International Minerals & Chemical Corp.'s Phosphate Minerals Div., has been advanced to the newly created position of production manager of the division. He will supervise from his headquarters in Bartow, Fla., the production facilities in both the Florida and Tennessee phosphate departments. He will report directly to the division's general manager, **Fred A. Koechlein.** Mr. Bowen has been with the company since 1926.

Kuno Doerr, Jr., manager of the East Helena, Mont., American Smelting & Refining Co. since March 1947, has been made manager of Asarco's Garfield, Utah, plant. He will have his offices in Salt Lake City. Mr. Doerr, a graduate of Colorado School of Mines, was employed in 1927 at the Garfield plant as a chemist. In 1940 he was made assistant superintendent and in 1941 he was appointed assistant manager of the Utah dept. He will be succeeded by **Joseph T. Roy,** East Helena plant superintendent since 1948. Mr. Roy, after graduation from Montana School of Mines in 1929, went to the East Helena plant as a chemist and in 1933 was advanced to metallurgist. In 1936 he became assistant superintendent of the East Helena plant and in 1942 was advanced to superintendent of Asarco's lead smelter at Selby, Calif. **Stanley Lane,** assistant superintendent of the East Helena plant since 1949, has been made plant superintendent. Mr. Lane was graduated from MIT in 1935, and with the exception of army service, has been continuously employed ever since at the East Helena plant.

N. de VOOGD

N. "Doc" de Voogd is back in the Belgian Congo, after spending six months in Europe on leave. He may be reached c/o C. N. Ki, P. O. Box 91, Bukavu, Belgian Congo.

V. S. Barlow was appointed superintendent of mines, Utah Copper Div., Kennecott Copper Corp., Salt Lake City, and **Ernest C. Simkins** was named assistant mine superintendent. These positions were incorrectly listed in MINING ENGINEERING for January 1955, page 91.

H. Byron Mock, U. S. Bureau of Land Management area administrator for Utah, Idaho, Arizona, and Nevada in Salt Lake City, has announced his resignation. Mr. Mock, who came to Salt Lake City in 1941 as chief counsel for U. S. Grazing Service, an agency since combined with the General Land Office in the Bureau of Land Management, plans to enter the public land field. As the Government's representative, he directed the Snow Relief Program in the winter of 1949 that provided air lifts to save thousands of head of livestock.

Frank E. Thurston is at Black Lake, Megantic County, Que., and is now employed by the Asbestos Corp. Ltd. as mining superintendent of the Beaver mine.

Robert S. Rose, Jr., now associate research director, Atlas Powder Co., Wilmington, Del., has been named acting director of the research dept. Mr. Rose has served on the Atlas research staff since 1935.

Christian F. Beukema, vice president of Michigan Limestone Div., U. S. Steel Corp., since March 1954, has been appointed president. He succeeds **Hugh S. Lewis** who will continue with U. S. Steel in a consulting capacity. Mr. Beukema joined Michigan Limestone shortly after graduating from Michigan State College in 1940.

Personals Cont'd.

R. L. Prain will assume the title of president of the Roan, Mufulira, Rhodesian Selection Trust, and Chibuluma companies, of which in addition he is chairman. **R. M. Peterson,** at present technical director of the four companies, will become technical vice president.

William G. Pitt, who was with National Carbon Co., Div. of Union Carbide & Carbon Corp., Clarksburg, W. Va., is now in New York and is assistant manager of National Carbon's new products engineering.

A. L. Fairley, Jr., has been elected vice president, Shenango Furnace Co., and will be located at the executive offices in Pittsburgh. Mr. Fairley has been with this company since 1946 and previous to his recent appointment was assistant vice president. He will be in charge of all raw material operations, including raw material sales and purchases. He will also be manager of pig iron sales.

Joseph M. Denney has been appointed as a research associate in the metallurgy dept., General Electric Research Laboratory, Schenectady, N. Y. Mr. Denney was formerly a research engineering consultant with North American Aviation Co.

WILLIAM S. MOUNCE

William S. Mounce, a member of the New England Technical Field Section of the Development & Research Div., International Nickel Co. Inc., since 1945, has been appointed to the company's New York office as a member of the division's constructional Alloy Steel Section.

Earl E. W. Kearly, mining engineer with American Smelting & Refining Co.'s Northern Peru Mining & Smelting Co., Trujillo, Peru, is now a trainee with Magna Copper Co., Superior, Ariz.

Arthur Linz, vice president of Climax Molybdenum Co., has resigned to open his own offices as a technical consultant at 551 Fifth Ave., New York. Mr. Linz, who joined Climax in 1936 as a chemical engineer to start developing application of molybdenum in chemical and allied industries, became a vice president of the company in 1942 and was placed in charge of conversion operations and chemical sales and research. He is well known in the fields of dyestuffs, pigments, chromium, molybdenum, titanium, tungsten, uranium, and vanadium compounds and has had more than 100 patents issued to him in these and allied fields.

Alan Stanley, formerly metallurgist with American Cyanamid Co., Winchester, Mass., is now a development chemical engineer with this company in Piney River, Va.

Frederick C. Green, assistant general manager, Kennecott's Utah Copper Div., has been elected to the Board of Governors, Salt Lake City Chamber of Commerce.

Clarence B. Randall, chairman Inland Steel Co., Chicago, is the author of an article on Ishpeming, Mich., which appeared in the "favorite towns" series in *The Chicago Tribune Magazine* January 9. Mr. Randall practiced law in Ishpeming from 1915 to 1925. His books include *Freedom's Faith, A Creed for Free Enterprise,* and *Foreign Economic Policy for the United States.*

(Continued on page 308)

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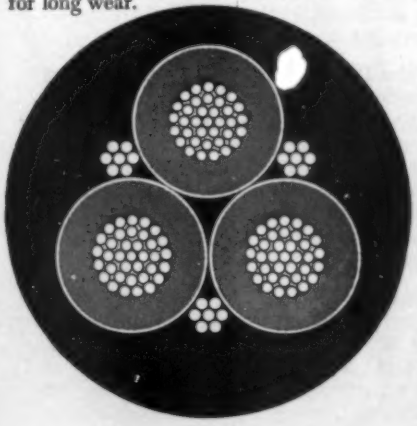

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Personals Cont'd.

A. C. "Alec" Munro retired January 1 after 32 years of service with Britannia Mining & Smelting Co., Britannia Beach, B. C. During most of this time he was general superintendent of mills. Mr. Munro is at present residing at Douglas, Ariz.

F. L. Knouse, assistant director, Rare & Miscellaneous Metals Div., Defense Minerals Exploration Administration, while recently on leave completed a consulting job investigating various columbite-tantalite, rutile, and gold occurrences in British Guiana.

J. M. Elias is now exploration geologist for Anaconda Copper Mining Co. in Grants, N. M. He was with Anaconda in Butte, Mont.

Theron G. Gerow has opened an office at 307 N. Michigan Ave., Chicago. Mr. Gerow, formerly president West Virginia Coal & Coke Corp., Cincinnati, will specialize in strip mining, planning and plant layout, coal preparation operations, and river coal loading and unloading terminals.

J. F. Wickham, graduate of the University of Arizona, has been appointed to the position of mill superintendent at the Nuestra Señora Unit of American Smelting & Refining Co. in Mexico.

L. F. LABOW

Larry F. Labow has been appointed managing director of Pardee Amalgamated Mines Ltd., Toronto, a mining organization engaged in the development of various scattered properties across Canada. Mr. Labow is a B.Sc. graduate in mining engineering from Queens University, Kingston. He has been engaged in various phases of mining for the past 20 years, in engineering and managerial capacities in Sudbury, Porcupine, Valdor, Red Lake, Kenora, and Kirkland Lake. Mr. Labow has been manager, Technical Mine Consultants, Toronto, since 1953.

H. J. Vander Veer, lands and mineral staff officer, Region II, Bureau of Land Management, U. S. Dept. of the Interior, resigned last month after nearly 20 years in the federal service on mineral problems. He has established the H. J. Vander Veer & Associates, a consulting firm in the Judge Bldg., Salt Lake City. The firm will act in oil and gas, mining, public land, and survey capacities.

Frank R. Hunter has been appointed division geologist for the Industrial Minerals Div., International Minerals & Chemical Corp., Chicago. He will direct an expanded exploration program for the division. Mr. Hunter became associated with International in 1945 and has been a section leader in the Research Div. He received a Ph.D in geology at Cornell University and spent two years as a geologist with the Texas Co. before joining International.

John D. Russell, who was manager of engineering, Joy Mfg. Co., has been appointed vice president, engineering, with headquarters at Joy's executive offices in the Oliver Bldg., Pittsburgh. Mr. Russell has served the company in various engineering capacities since his graduation from Cornell University in 1930.

Charles R. Hubbard has resigned as mining engineer for the U. S. Bureau of Mines, Mining Branch, Region VI, Rolla, Mo., to accept a position as mining engineer, Idaho Bureau of Mines & Geology, University of Idaho, Moscow.

James R. Russell is manager of Atlas Powder Co.'s eastern district, a new sales area with headquarters in New York. This is a consolidation of the New York and Tamaqua, Pa., explosives sales districts. **A. F. Hutcheson** will continue as resident manager of the Tamaqua office, which now operates as a suboffice under New York. **W. C. Manning**, formerly manager of the New York district, will handle specialized sales problems in the New York area.

Donald W. Schmidt has been named to the industrial engineering dept., Kennecott Copper Corp.'s Chino Mines Div. and assigned to the open pit mine branch at Santa Rita, N. M. Mr. Schmidt, who has been with Chino since 1953, was formerly with Kennecott's subsidiary, Braden Copper Co., Sewell, Chile.

Paul D. Sullivan has been named assistant sales manager, Le Roi Div., Westinghouse Air Brake Co., Milwaukee. Mr. Sullivan joined Le Roi more than a year ago and has been in charge of contractor sales in New York. He will be concerned primarily with promoting the sale of Le Roi portable air compressors and Westinghouse stationary air compressors, both manufactured by Le Roi Div. in Milwaukee.

STEPHEN M. SHELTON

Stephen M. Shelton, director of Region I, U. S. Bureau of Mines, Albany, Ore., was recently given a distinguished service citation for metallurgical achievements. He joined the USBM in 1935 in Reno, Nev.

Samuel S. Arentz of Salt Lake City, assistant to the president of Combined Metals Reduction Co., has resigned to devote his time to a consulting service. He will also be consultant to Combined Metals and is serving currently as president of the related Comet Mines and Caselton Milbank companies. Mr. Arentz, who joined the firm in 1941 as mining engineer-geologist at its Nevada properties, advanced successively to mine superintendent, general superintendent, and manager of operations.

(Continued on page 310)

Personals Cont'd.

John C. Neemes, Jr., of International Nickel Co. Inc., has been elected a chairman of the mining and metallurgy committee of the Alumni Assn. of the Institute of Technology, University of Minnesota. Mr. Neemes has been in charge of the Inco Development & Research Division's Twin Cities Technical Field Section at Minneapolis since it was opened in January 1946.

David D. Baker has been appointed deputy director of the Mining Div., Grand Junction operations office, Atomic Energy Commission, Grand Junction, Colo. Before joining the AEC in 1954 as staff engineer in the Exploration Div., Grand Junction, Mr. Baker was employed by Utah Construction Co. as manager of a contract between this company and the Korean Government for the rehabilitation of tungsten mines in Korea. He has also been employed by Union Mines Development Co., Pacific Mining Co., Alaska-Juneau Co., U. S. Vanadium Co., Big Horn Mining Co., and American Smelting & Refining Co.

T. M. Waterland on January 1 was made assistant manager of Howe Sound Co.'s Britannia Mining & Smelting organization, Britannia Beach, B. C. **A. T. Smith** is now assistant mine superintendent.

WILLIAM E. CONNOR

William E. Connor has been appointed manager of electric utility sales for the middle Atlantic sales region, Federal Pacific Electric Co., Newark, N. J. Mr. Connor was formerly mechanical superintendent, Lehigh Navigation Coal Co., Lansford, Pa. He joined Lehigh in 1942.

George M. Potter is being transferred by the U. S. Bureau of Mines from Washington, D. C., to an assignment in Mexico as party chief and metallurgical engineer on technical cooperation activities. Mr. Potter's assignment is for two years and his headquarters will be in Mexico City. His address will be c/o American Embassy.

Oscar H. Johnson (AIME Director 1943 to 1946) retired as chairman of the board, Mine & Smelter Supply Co., Denver, January 1. Mr. Johnson formerly president, was for many years manager of Mine & Smelter's Marcy mill dept. He was born in Chicago and went to Salt Lake City in 1898 where he was first employed by Trent Engineering & Machinery Co. In 1905 Mr. Johnson became connected with Allis-Chalmers Co., Salt Lake City branch as assistant manager to **Frank E. Marcy.** In 1912 Mr. Marcy and he transferred to Mine & Smelter Supply Co., first in the operation of the branch in Salt Lake City, later in Denver. Among many other activities, Mr. Johnson served during World War II as a member of the War Production Board's mining equipment industry advisory committee. He will continue to reside in Denver.

A. R. Astiazarán has resigned his position as metallurgist for San Francisco Mines of Mexico Ltd., San Francisco del Oro, Chihuahua, Mexico, to accept a position as branch manager with Maquinaria General del Occidente S.A., Obregon, Sonora, Mexico. This company is a distributor for Caterpillar Tractor Co.

Stewart W. Tresouthick, who was with Alpha Portland Cement Co., Easton, Pa., is now process engineer for Universal Atlas Cement Co., Fairborn, Ohio.

ALAN PROBERT

Alan Probert has resigned from the U. S. Bureau of Mines to accept a position as vice president and general manager of Cía. Minera de Guatemala S. A. His headquarters will be in Guatemala City. Mr. Probert was graduated in metallurgy from the University of California in 1925. After extensive experience including important executive positions in mineral production in Mexico, the West, and Alaska, he joined the USBM in 1949 as chief of the technical assistance team in Mexico. Within a year Mr. Probert was called to Washington to serve as assistant director of the USBM's Foreign Minerals Region with full responsibility for management of its worldwide technical assistance operations. Upon leaving the USBM, he was awarded the Department of Interior's silver medal for Meritorious Service.

John F. Emerson is now mine superintendent, U. S. Vanadium Co., Pine Creek mine, Bishop, Calif. **Lawson A. Wright** is chief engineer and **Wilmer H. Witt** is mine foreman.

Jack White is returning to Northern Nigeria where he is taking up the appointment of general manager of the Jantar Nigeria Co. Ltd.

Manning W. Cox of Wallace, Idaho, and Kingman, Ariz., has resigned as chief geologist, Northwestern mining dept., American Smelting & Refining Co., Wallace, Idaho. He will devote his time to personal mining enterprises and hopes to be free by April or May to serve as mining consultant. Mr. Cox was graduated from the University of Washington in 1940. After studying at Yale, he worked with the U. S. Geological Survey, then with U. S. Smelting Co., and joined Asarco in 1946. In his work throughout the U. S. and in parts of Canada, Alaska, Peru, Cuba, and North Africa, Mr. Cox has dealt with mineral scouting; geochemical, geophysical, and physical exploration and mine development; with underground and open-pit mine layout; and with mineral economics and contract negotiations. He may also be reached through Box 37, Yucca, Ariz.

Harry O. Zimmerman, formerly assistant to the manager, has been appointed manager, Inland Steel Co. coal properties. Wheelwright, Ky. He succeeds the late **John T. Parker.** Mr. Zimmerman started with the company as chief engineer when Inland acquired its first coal property at Wheelwright in 1930. Active in many organizations of the coal industry, Mr. Zimmerman is a vice chairman of the Central Appalachian Section, AIME, and a member of the Kentucky Mining Institute.

Parke A. Hodges and **A. F. Banfield,** who recently returned from Spain, and **Elliott E. Check,** all of Behre Dolbear & Co., New York, have gone to Nigeria on professional work.

T. V. Canning, metallurgist, for the past three years with Oglebay, Norton & Co., Duluth, is now with National Lead Co., New York.

John W. Svanholm, for some time consulting economic geologist for the Burmese Government Mineral Resources Development Corp., is one of the men taking an active part in the growth of Burma's mining industry. Previous to this appointment, Mr. Svanholm studied new developments in mining and geophysics in Sweden, Canada, and the U. S. He was formerly active in the Philippines, Roumania, Germany, and Yugoslavia as an engineer-geologist in private practice as well as in corporation and government service.

OBITUARIES

Memorial Resolution
in honor of
Peter M. Anderson

Whereas, with the passing of Peter M. Anderson in Johannesburg, Union of South Africa, on Nov. 5, 1954, the Institute lost one of its distinguished Honorary Members;

Whereas, throughout his professional life of 52 years P. M. Anderson gave much to the sound development of deep mining on the Rand, and to technical education and professional development in the Union of South Africa;

Whereas, during his active life Mr. Anderson has served as an inspiration to young South African engineers and as an example of what one man can accomplish in the promotion of the general welfare of the Union by his fine character, leadership, and great understanding;

Whereas, Mr. Anderson was made an Honorary Member of the AIME in 1946, after having a similiar honor conferred upon him by the Institution of Mining and Metallurgy, after serving his own country in many capacities of industrial and community leadership;

Therefore Be It Resolved, the American Institute of Mining and Metallurgical Engineers records with deep sorrow the loss of this world-distinguished engineer and friend, and;

Be It Further Resolved, that this resolution be included in the minutes of this meeting, and a copy be sent to the family of the late Peter Maltitz Anderson.

by H. DeWitt Smith

Jerome B. Landfield (Legion of Honor Member 1902) of San Francisco died Nov. 22, 1954, an hour after he was struck by a car. Mr. Landfield was a professor of history and Slavonic languages at the University of California, Berkeley, and an advisor on Russian affairs to the State Department. He was born in 1871 in Newark Valley, N. Y., and received his A.B. from Cornell University in 1894. After several years of graduate work, Mr. Landfield went to Russia in 1898 to make mine examinations on the Kirghiz Steppe. He was also a member of the Samoa expedition of the East Siberian Syndicate to northeastern Siberia and Alaska in 1900. Mr. Langfield was later with Cal King Gold Mining Co., Picacho, Calif., with the Russian Economic League in New York, and an editor of *The Weekly Review* in New York. In recent years he worked at the Verdier Cellars of the City of Paris in San Francisco and edited *Cellar Chats*. He was an active leader in the Bohemian Club in San Francisco.

Florence Robertson (Member 1950) died Nov. 18, 1954. She was professor of geophysics and geophysical engineering at Saint Louis University. She was listed in *American Men of Science* and was one of the only two renowned seismologists in the world. Miss Robertson was born in Paris, Texas, in 1909. She received her A.B. and A.M. degrees from Texas Technological College and was an instructor in physics at this college the summer of 1936. One of only four women in the world who held doctorates in geophysics, Miss Robertson received her Ph.D. from Saint Louis University in 1945. She joined the faculty as an instructor after having served for three years as a graduate fellow. Miss Robertson served as chairman of the Eastern Section of the Seismological Society of America and was a member of the Society of Exploration Geophysicists and a fellow of the Geological Society of America and the American Physical Society.

Neurology

Date Elected	Name	Date of Death
1921	David Atkins	Unknown
1921	Crosby F. Baker	Dec. 9, 1954
1918	J. J. Cadot	Jan. 19, 1955
1916	G. Lister Carlisle	Dec. 22, 1954
1914	John A. Dresser	Unknown
1937	W. R. Ellis	Jan. 30, 1955
1939	David E. Green	Dec. 1, 1954
1918	Vladimir A. Grodsky	Jan. 6, 1955
1952	Robert L. Hardy	Dec. 29, 1954
1945	Harmon G. Lichtenstein	Unknown
1942	John T. Parker	Jan. 12, 1955
1936	W. W. Simon	Jan. 11, 1955
1898	James Underhill	Apr. 22, 1954

George A. Schroter

An Appreciation by
G. Austin Schroter

George A. Schroter (Member 1904), longtime and well-known mining engineer and ore dressing metallurgist, died in New York on Nov. 15, 1954 at the age of 83 years.

One of the remaining handful of "old-timers" famous around the turn of the century and early 1900's, Mr. Schroter was born in Hannibal, Mo., grew up in Denver when the Colorado mining industry was in its heyday. Deciding early in life to make mining engineering his career, "Uncle George," as he was known to the industry, was educated in the Denver public schools, finishing his technical education in Brooklyn Polytechnic Institute and Columbia University, where he received his degree with the class of '93.

His initial experience was gained as a young engineer in Colorado mines, and before long he was appointed superintendent and metallurgist of Rico Smelting & Refining Co. He met with such success in this and other jobs that he was retained as consulting engineer by a group of Eastern and British companies and was active in examination and development of a number of properties in South and Central America and in Russia.

He then became consulting mining engineer. During his association with the late John Hays Hammond, for the Venture Corp. Ltd. of Lon-

don, he was active in the development and operation of such famous properties as Stratton's Independence and Camp Bird in Colorado, the Esperanza at El Oro, Mexico, and the Oroville Dredging Co. in California. "Uncle George" and John Hayes Hammond were the kingpins of modern operation of the famous old Real del Monte at Pachuca, which old-timers will remember.

Next, as consultant for Mines Co. of America, he was active in management of such Mexican operations as Dolores, El Rayo, Creston Colorada, and La Dura Mining & Milling Co. It was on the Creston Colorada job in 1906 that he met W. C. Laughlin who was "trouble shooting" the cyanide plant, and the two shortly thereafter became partners in the operation of the highly successful San Xavier mine in Sonora. This friendship was to continue for close to 50 years.

"Uncle George" was an old revolution hand in Mexico and managed to keep on friendly terms with both sides of the Diaz and succeeding revolutions. At one time Pancho Villa, an old miner himself, agreed to safeguard the movement of bullion to Nogales in return for half the metal. Ultimately, too many Yanquis on the warpath, difficulties of transportation connected with the revolution, and the declining price of silver, brought an end to a romantic and flourishing saga, and the mine closed in 1922.

Mr. Schroter was a bluff and genial figure in New York and Western mining circles for half a century, and was connected intimately with early operations of such companies as Miami, Bagdad, and other porphry coppers. He was noted for his engineering thoroughness and the meaty brevity of his reports, and is said by the late D. W. Brunton to have written the shortest and most complete mine examination report on record. This report, summarizing findings on a Central American property was written on the back of an envelope and consisted of two letters—"N. G."

For many years Mr. Schroter was a member of the Denver Club, the Denver Athletic Club, the Mining and Phi Gamma Delta Clubs of New York, and was a trustee of the College of Mines of Columbia University. He was elected a member of the Legion of Honor of the AIME in 1954.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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Coming Events

Mar. 16, AIME, Connecticut Local Section, annual meeting, Statler Hotel, Hartford, Conn.

March 17, AIME, Utah Section, Aims, Functions, and Organization of the USBM, panel discussion, Salt Lake City.

Mar. 20-23, American Institute of Chemical Engineers, Kentucky Hotel, Louisville.

Mar. 28-Apr. 1, Ninth Western Metal Exposition, Pan-Pacific Auditorium, and Ninth Western Metal Congress, Ambassador Hotel, Los Angeles.

April 9, AIME, Utah Section, Spring Dinner Dance, Salt Lake City.

Apr. 13, Material Handling Institute, spring meeting 10:00 am, Drake Hotel, Chicago.

Apr. 14, AIME, Cleveland Section, joint meeting with American Ceramic Society, NACA Laboratories, Cleveland Hopkins Airport.

Apr. 18-19, Third National Air Pollution Symposium, Pasadena, Calif.

Apr. 18-20, AIME, Blast Furnace, Coke Oven and Raw Materials, and National Open Hearth Steel Conferences, Bellevue-Stratford Hotel, Philadelphia.

Apr. 18-22, American Society of Mechanical Engineers, Diamond Jubilee spring meeting, Lord Baltimore Hotel, Baltimore.

Apr. 19-21, Canadian Institute of Mining and Metallurgy, annual meeting, Royal York Hotel, Toronto.

April 21, AIME, Utah Section, How the Oil Industry Operates, panel discussion, Salt Lake City.

Apr. 22-23, AIME, New England regional conference, Boston.

Apr. 28-29, American Zinc Institute, 37th annual meeting, Drake Hotel, Chicago.

Apr. 28-30, AIME, Pacific Northwest Conference, Spokane.

May 1-4, American Institute of Chemical Engineers, Shamrock Hotel, Houston, Texas.

May 16-19, American Mining Congress, 1955 Coal Show, Cleveland.

May 19, AIME, Utah Section, joint meeting with University of Utah Student Chapter. Speaker: Eugene Callaghan, director, New Mexico Bureau of Mines & Mineral Resources.

June 1-18, Joint Metallurgical Societies, European meeting.

June 20-24, American Society of Engineering Education, 63rd annual meeting, Pennsylvania State University, State College, Pa.

June 26-July 1, American Society for Testing Materials, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 19-22, AIME, Industrial Minerals Div., fall meeting, Asheville, N. C.

Oct. 2-5, AIME MGGD fall meeting and Black Hills regional meeting of the Ind. Min. Div., Rapid City, S. D.

Oct. 5-8, AIME, Minerals Beneficiation Div., fall meeting, Salt Lake City.

Oct. 6-8, AIME, Utah Section, Rocky Mountain Industrial Minerals Conference, Salt Lake City.

Oct. 10-13, American Mining Congress, Metal Mining—Industrial Minerals Convention, Las Vegas, Nev.

Oct. 19-20, ASME, AIME, fuels conference, Neil House, Columbus, Ohio.

Nov. 13-18, American Society of Mechanical Engineers, Diamond Jubilee annual meeting, Congress, Hilton, and Blackstone Hotels, Chicago.

Feb. 20-23, 1956, AIME, Annual Meeting, Statler and New Yorker hotels, New York.

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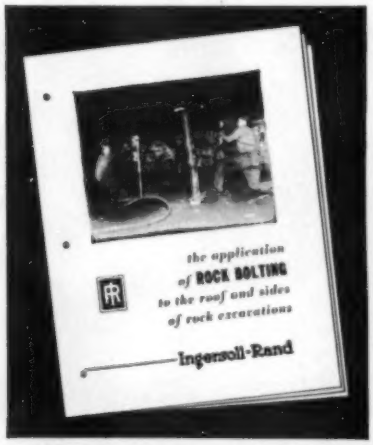

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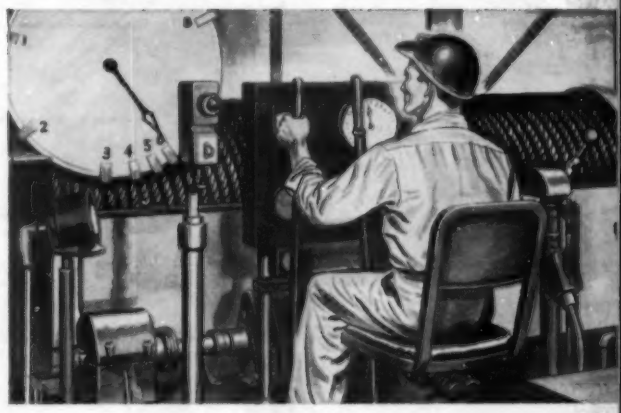

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